BEST MANAGEMENT PRACTICES

Application of Municipal Sewage Biosolids to Cropland

Canada

Ontario

OFA Ontario Federation of Agriculture

What is a Best Management Practice or "BMP"?

- a proven, practical and affordable approach to conserving soil, water and other natural resources in rural areas

Who decides what qualifies as a BMP?

- a team that represents many facets of agriculture and rural land ownership in Ontario, including farmers, researchers, natural resource managers, regulatory agency staff, extension staff and agribusiness professionals

What is the BMP Series?

- innovative, award-winning books presenting many options that can be tailored to meet your particular environmental concern and circumstances
- current BMP titles are:

Application of Municipal Sewage Biosolids to Cropland
Buffer Strips
Cropland Drainage
Deadstock Disposal
Establishing Tree Cover
Farm Forestry and Habitat Management
Field Crop Production
Fish and Wildlife Habitat Management
Greenhouse Gas Reduction in Livestock Production Systems
Horticultural Crops
Integrated Pest Management
Irrigation Management
Livestock and Poultry Waste Management
Managing Crop Nutrients
Manure Management
No-Till: Making It Work
Nutrient Management
Nutrient Management Planning
Pesticide Storage, Handling and Application
Soil Management
Streamside Grazing
Water Management
Water Wells
Woodlot Management

How do I obtain a BMP book?

- order **online** through ServiceOntario http://www.publications.serviceontario.ca/ecom/
- order **by phone** through the ServiceOntario Contact Centre

Monday–Friday, 8:30 am–5:00 pm
416-326-5300
416-325-3408, TTY
1-800-668-9938, toll-free across Canada
1-800-268-7095, TTY toll-free across Ontario

- order **in person** at ServiceOntario Centres located across the province

METRIC–IMPERIAL CONVERSION FACTORS

Convert		To		Metric
%	►	kg/1000 L	multiply by	10
%	►	kg/tonne	multiply by	10
mg/L	►	%	divide by	10,000

Convert		To		Imperial
%	►	lbs per 1000 gallons	multiply by	100
%	►	lbs per ton	multiply by	20
ppm	►	%	divide by	10,000

Note: 1 m^3 = 1000 L; 1 tonne = 1,000 kg or 2,205 lb; 1 ton = 2,000 lb.

UNITS OF MEASURE

While Canada "went metric" over 30 years ago, many commonly used measurements such as land area are still expressed using imperial units. Acres of land are a good example: landowners seldom refer to the size of their property in hectares. For your convenience, most of the measurements used in this book are provided in both metric and imperial units. However, where common usage, common sense, space limitations or regulatory concerns dictate, one or the other may appear exclusively.

CONVERSION FROM...	FACTOR	EXAMPLE
METRES TO FEET	1 metre = 3.281 ft	A 20.6-m tall tree is 67.6 ft (20.6 x 3.281)
FEET TO METRES	1 foot = .3048 m	A 100-ft buffer is 30.48 m (100 x .3048)
ACRES TO HECTARES	1 acre = .405 ha	A 35-ac field is 14.16 ha
HECTARES TO ACRES	1 hectare = 2.47 ac	A 1.4-ha plot is 3.5 ac

CONVERSIONS – METRIC AND IMPERIAL

Common Conversions

1 gallon	=	4.546 litres	1 acre	=	0.405 hectare
1 gallon	=	1.201 US gallons	1 acre	=	43,560 $feet^2$
1 gallon	=	0.161 cubic feet	1 lb/ac	=	1.12 kilogram/hectare
1 US gallon	=	3.785 litres	1 ton/ac	=	2.25 tonnes/hectare
1 US gallon	=	0.833 imp gallon	1 gal/ac	=	11.2 litre/hectare
1 ton	=	0.907 tonne	1000 gal/ac	=	11,200 litre/hectare
1 pound	=	0.454 kilogram	1000 gal/ac	=	11.2 $metre^3$/hectare
1 tonne	=	2,205 pounds	1 metre	=	3.28 feet
1 $foot^3$	=	6.229 gallons	1 metre	=	39.4 inches

Application Rate Conversions

Metric to Imperial (Approximate)		Imperial to Metric (Approximate)	
Litres per hectare x 0.09	= gallons per acre	Gallons per acre x 11.23	= litres per hectare (L/ha)
Litres per hectare x 0.36	= quarts per acre	Quarts per acre x 2.8	= litres per hectare (L/ha)
Litres per hectare x 0.71	= pints per acre	Pints per acre x 1.4	= litres per hectare (L/ha)
Millilitres per hectare x 0.015	= fluid ounces per acre	Fluid ounces per acre x 70	= millilitres per hectare (mL/ha)
Grams per hectare x 0.015	= ounces per acre	Tons per acre x 2.24	= tonnes per hectare (t/ha)
Kilograms per hectare x 0.89	= pounds per acre	Pounds per acre x 1.12	= kilograms per hectare (kg/ha)
Tonnes per hectare x 0.45	= tons per acre	Ounces per acre x 70	= grams per hectare (g/ha)
Kilograms per 1000 L x 10	= pounds per 1,000 gallons	Pounds per ton x .5	= kilograms per tonne (kg/t)

CONTENTS

INTRODUCTION

THIS CHAPTER WILL:

- **introduce some basic terminology**
- **provide an overview of the laws that govern the application of biosolids to farmland**
- **outline who's responsible for what, and**
- **conclude with a brief look at the issue of risk management.**

The application of municipal sewage biosolids to cropland has become a highly charged topic in some Ontario rural communities.

Some people want the practice banned outright, feeling that any level of risk is unacceptable. Others are uncertain, seeking reassurance that current regulations are sufficiently strict to keep risks to the environment and human health to a minimum.

And some people are proponents, believing it's the preferred option to disposal in landfills or incineration. They see in it an opportunity to recycle safe, nutrient-rich materials to the land – closing the loop in nutrient production, consumption, and reapplication for production.

This book aims at helping everyone involved – sewage biosolids generators, haulers, farmers and their neighbours – become better informed about application to cropland. We will look at:

- ▶ benefits and risks
- ▶ what's in sewage biosolids
- ▶ sewage biosolids as sources of crop nutrients
- ▶ how sewage biosolids are treated and tested for suitability
- ▶ best management practices for storing, transporting, handling, and applying in accordance with legislation, regulations, protocols, and guidelines
- ▶ nutrient management planning for sewage biosolids
- ▶ legislative requirements for land application.

This book describes best management practices for municipal sewage biosolids. For brevity's sake, the term may be abbreviated to "sewage biosolids" or simply "biosolids."

Farmers can save fertilizer costs and produce high-yielding crops with land-applied sewage biosolids.

Land application of biosolids is one way of recycling nutrients back to cropland. Food for public consumption or grains for livestock feeds are exported from rural farmland for further processing and consumption. Once consumed, the nutrients and organic matter from treated human wastes or biosolids can improve soil quality and provide nutrients for crop and fibre production on agricultural land.

Wastewater treatment plants process and clean wastewater. Biosolids are by-products of these treatment plants.

Sewage biosolids are "stabilized" to make them more suitable for land application.

BIOSOLIDS TERMINOLOGY

Here are some definitions to help clarify what is meant by biosolids application. For a complete list of definitions, please see the Glossary on page 109.

Agricultural utilization – the use of biosolids that are acceptable for cropland application as a source of nutrients and organic material to improve soil fertility and physical properties, including tilth and water-holding capacity. This book focuses exclusively on this type of biosolids material.

Best management practice (BMP) – a proven, practical, and affordable approach to conserving soil, water, and other natural resources in rural areas.

Biosolids and ***sewage sludge*** – biosolids are treated sewage sludge. As a term, "biosolids" comes from the method of production, i.e., the biological processing of wastewater solids. Biosolids are treated and managed in accordance with regulatory standards.

Domestic septage – household waste that is a mixture of liquids and solids removed from septic tanks and holding tanks. The nutrient content of domestic septage is similar to sewage sludge and, when treated and processed, can also be land-applied as an organic nutrient source.

Sewage biosolids must be properly treated and tested to meet the criteria for land application.

To learn more about domestic septage, please see this Septic Smart publication: http://www.omafra.gov.on.ca/english/environment/facts/sep_smart.htm

Municipal sewage biosolids – nutrient-rich organic materials created as a by-product from the processing of municipal sewage in a treatment facility or wastewater treatment plant (WWTP). When treated and processed to meet provincial standards, these residuals can be recycled and applied as soil amendments and fertilizer to improve or maintain soil productivity.

NASM – non-agricultural source materials. Includes but is not limited to sewage biosolids, paper mill biosolids, food processing washwaters, and organic matter from food processing.

NASM plan – a nutrient management plan for non-agricultural source materials, including sewage biosolids.

Risk management – decision-making directed towards the effective management of potential opportunities and adverse effects.

Sewage treatment plant – see *wastewater treatment plant.*

Wastewater – water that carries wastes from homes, institutions, businesses, and industries. It's a mixture of water and dissolved or suspended solids.

Wastewater treatment plant (WWTP) – a facility designed to remove contaminants from raw or untreated municipal sewage. This includes physical, chemical, and biological processes that result in two materials: treated effluent (water) and biosolids. A multi-barrier approach is used to ensure that the treated effluent (water) is of suitable quality for release into the natural environment. This process also produces biosolids of suitable quality to be returned to the environment.

Septage, or wastes from rural household septic cleanouts, may be hauled to WWTPs for treatment. It is a best management practice that septage be treated prior to land application.

LEGISLATIVE CONTROLS AND KEY PLAYERS

The management of biosolids in Ontario has two legislative acts and a network of regulations that specify roles and responsibilities.

Regulations were developed to ensure that any biosolids being applied to land do not degrade the natural environment or pose harm to human or animal health.

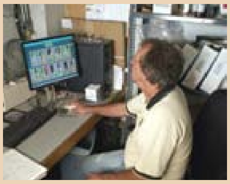
Regulations within the following two acts work together by establishing standards for materials composition, management and transport, siting, land application, monitoring and record-keeping, and approvals for agricultural use:

- Nutrient Management Act, 2002
- Environmental Protection Act.

The Ontario Water Resources Act and associated regulations control the operation of municipal sewage treatment plants.

On a local level, most municipalities have in place wastewater source management initiatives, including bylaws regarding municipal sewer use. These initiatives do much to control the quality of raw sewage received at sewage treatment plants.

Want more information? A whole chapter is devoted to the topic of regulatory controls for the land application of biosolids in Ontario, beginning on page 95.

KEY PLAYER	ROLES AND RESPONSIBILITIES
MUNICIPALITY (as biosolids generator) **Wastewater treatment plant operators are skilled professionals, trained to operate the plant to produce clean water and biosolids from raw municipal sewage.** 	• for the most part, municipalities generating biosolids destined for land application are responsible for producing biosolids that meet the quality criteria for land application • municipalities must provide NASM plan developers and farmers with up-to-date analytical results regarding the quality of the sewage biosolids for land application
HAULER/APPLICATOR 	• a hauler is responsible for the safe and effective transfer and application of biosolids according to regulatory requirements
FARMER 	• the farmer or receiver of the land-applied biosolids is primarily responsible for timing concerns – determining when the material is applied and adhering to the waiting periods before crop harvest or grazing • all farmers must comply with their approved NASM plans and the requirements of Ontario Regulation 267/03, the Nutrient Management Regulations
NON-AGRICULTURAL SOURCE MATERIALS (NASM) PLAN DEVELOPER	• the NASM plan developer is a trained and certified person responsible for the development of a NASM plan
PROVINCIAL GOVERNMENT Ontario	• the Ontario government is responsible for research, development, education, certification, and enforcement of a science-based regulatory framework

Few actions in agriculture are entirely risk-free. This is a fact of life. The challenge for everyone – scientists, policy-makers, and citizens – is to determine and manage a socially acceptable level of risk.

RISK MANAGEMENT AND THE MULTI-BARRIER APPROACH

Risk management can be defined as decision-making directed towards the management of potential opportunities and adverse effects.

Regarding the land application of sewage biosolids, potential adverse effects are mitigated by a series of risk management measures. This multi-barrier approach involves:

- municipal sewage bylaws to control the quality of raw sewage
- regulatory requirements governing approval of the design and monitoring of WWTPs
- criteria that specify biosolids quality, and procedures for handling, site selection, and application
- mandatory training for biosolids applicators and staff
- mandatory NASM plans for all agricultural land where biosolids are applied
- regulatory oversight, including routine inspections and materials testing
- ongoing compliance promotion and education efforts on all fronts.

This multi-barrier system of procedural controls and practices makes land application protective of the environment, but not risk-free.

BIOSOLIDS OPTIONS – LANDFILL, INCINERATE, OR APPLY TO CROPLAND?

While few of us want to think of what happens with sewage, the fact is that it has to go somewhere after treatment. Seeing that it's handled safely, properly and efficiently is in everyone's best interest.

landfill – may be the least-expensive at present, but it comes with environmental risks such as methane emissions, the loss of valuable nutrients, and use of valuable landfill capacity

incineration – destroys many contaminants in biosolids, but the process is expensive, leaves concentrated chemicals in the ash, and may add to greenhouse gas emissions

land application – recycles beneficial organic matter and utilizes valuable nutrients that otherwise go to waste (literally). Although agricultural land application is not risk-free, the risks can be minimized through proper application management.

For more information about options, see the chapter beginning on page 24.

The key to successful sewage biosolids utilization is management, which is a combination of:

- nutrient management planning
- communication
- proper application methods
- best management practices, and
- all parties being aware of their responsibilities.

BENEFITS AND CONCERNS

THIS CHAPTER WILL:

- **describe the benefits and concerns of land application**
- **give a measure of the significance of some of the concerns, and**
- **explain how concerns are addressed.**

There are potential risks with applying biosolids to cropland – but there are real benefits to everyone as well.

Read on to find out more about how benefits outweigh concerns through new technology and improved management practices.

BENEFITS OF LAND-APPLYING SEWAGE BIOSOLIDS

URBAN-RURAL NUTRIENT RECYCLING

Land application is a practical and responsible way to close the loop of urban-rural nutrient recycling, and complete the nutrient cycle. Many stakeholders, including farmers as well as municipalities generating sewage biosolids, are concerned with environmental protection and resource conservation. They consider beneficial re-use preferable to incineration or disposal in a landfill.

Crop nutrients are returned to the land, closing the loop from crops to urban consumption and back to cropland.

COST-EFFECTIVENESS FOR TAXPAYERS

When all factors are taken into consideration, land application is often less expensive than alternative methods of management such as disposal in a landfill.

Land-applied biosolids can give cropland a boost. The added organic matter and nutrients improve soil quality and ultimately crop yields.

IMPROVED SOIL QUALITY AND CROP YIELDS

Sewage biosolids contain essential crop nutrients such as nitrogen and phosphorus as well as organic matter. All of these are needed in an agricultural production system in order to maintain soil quality and maximize crop yields.

The solid component of sewage biosolids is about 50% mineral material, which supplies most of the essential nutrients, and 50% organic matter, which is needed to maintain good soil structure, permeability, moisture-holding capacity, and natural fertility.

The enhanced colour and growth in the same crop due to biosolids application are significant.

REDUCED REQUIREMENT FOR OTHER FERTILIZERS

The amount of nutrients in sewage biosolids, especially nitrogen and phosphorus, allows farmers to reduce the amount of commercial fertilizer that must be obtained from other sources. Sewage biosolids are also a source of sulphur. The resulting nutrient cost-savings can be significant, depending on the type of sewage biosolids used and the crop grown following land application.

Biosolids applications reduce the need for additional fertilizer. This saves time, energy, and money.

ADDED MICRONUTRIENTS

Sewage biosolids also supply essential plant micronutrients. These are needed by crops for healthy growth, but may not otherwise be applied by farmers because crop response to their application is unpredictable. Some key micronutrients in sewage biosolids include manganese, zinc, copper, iron, and molybdenum.

Micronutrient deficiencies often show up during the growing season long after fertilizer materials have been applied. Regular use of biosolids can help to prevent deficiencies.

ADDED ORGANIC MATTER

Maintaining good soil tilth and fertility can be a challenge in Ontario soils as the organic matter lost through normal cropping practices can be greater than that returned to the soil by crop residues.

Adding organic matter from other sources such as sewage biosolids can help to improve seedbed structure – making it easier to till the soil. It will also help to improve the suitability of the soil as a seedbed. Adding organic matter to lighter, coarse-textured sandy soils also improves their moisture-holding capacity and minimizes soil erosion. Adding the organic matter found in sewage biosolids:

- ► increases water infiltration into the soil and soil moisture-holding capacity
- ► reduces soil compaction
- ► increases the soil's ability to retain and provide nutrients
- ► reduces soil acidification
- ► provides an energy source (carbon) for beneficial micro-organisms.

Biosolids applications can have an immediate and cumulative impact on soil organic matter levels – particularly with sandy soils where there are few other sources of organic matter additions.

Regular additions of sewage biosolids and other sources of organic matter will improve a soil's seedbed structure, moisture availability, and resistance to degradation.

To a fine-textured clay soil, adding organic matter found in biosolids will:

- help make the soil more friable and easier to work
- increase the amount of pore space available for root growth and entry of water and air into the soil.

In coarse-textured sandy soils, organic matter residues resulting from the application of biosolids can:

- increase the soil's water-holding capacity
- provide additional sites where nutrients can be held temporarily and exchanged for uptake by crop roots.

ENVIRONMENTAL CONCERNS AND HOW THEY'RE MANAGED

This section outlines key concerns and what's done to address them. The ✔ indicates actions that "receivers" (farmers) and/or land applicators are advised to take to minimize risk.

Environmental damage can occur when sewage biosolids or other nutrient-rich materials wash off fields and into waterways. Phosphorus and nitrogen can cause algal blooms, oxygen depletion, and fish kills.

IMPROPER OR EXCESSIVE ADDITION OF NUTRIENTS AND RISKS TO WATER QUALITY

Concerns

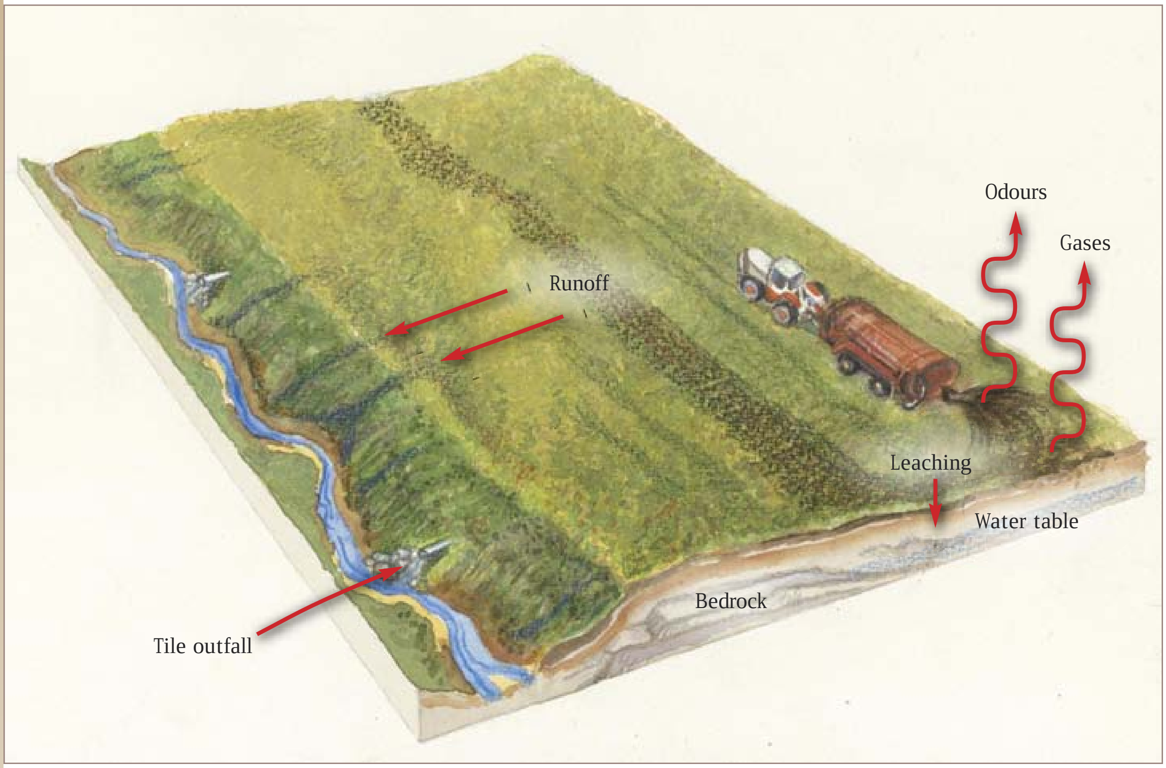
Improper soil fertility practices and excessive application rates can lead to high fertility levels. This is a potential risk with most nutrient sources, such as manure and commercial fertilizers.

Nitrogen and phosphorus in sewage biosolids, as in any fertilizer source, can be harmful and can adversely affect water quality if improperly applied or if applied in excess amounts. Excess nitrogen applied as a plant nutrient may move downward through the soil into groundwater, and phosphorus attached to soil particles may move off-site with eroded soil and then into surface water.

Management Response

- ✔ Test soils. Develop a nutrient management plan. Apply biosolids at rates required by crops, at times when crops can use the nutrients.
- ✔ Comply with regulatory specifications. Keep application operations at safe distances from environmentally sensitive areas.
- ✔ Apply only the amount of nitrogen needed and that can be utilized by the crop(s), so as to prevent excess nitrogen from reaching groundwater.
- ✔ Use conservation practices to prevent the potential contamination of surface water (ponds, streams or lakes) from eroded soil or runoff.

Soil and water conservation practices such as no-till and reduced tillage help keep soils and applied nutrients in place.



For the most part, environmental risk from land application of biosolids is similar to the potential risks from manure application. Risks are highest when poor management practices are employed on sensitive sites. For example, if surface-applied on sloping land adjacent to surface waters, crop nutrients from biosolids application can pose a risk to surface water where no precautions to prevent runoff have been taken. Examples of precautions include injection, crop residue, and buffer strips.

Heavy metals are present in biosolids. Sewer use bylaws and proactive industry initiatives have resulted in lowering concentrations in biosolids.

HEAVY METALS

Concerns

Heavy metals, known as the "regulated metals," occur naturally in the environment. For the most part there are low but measurable concentrations of heavy metals in sewage biosolids. Eleven of these elements have been identified as of concern when sewage biosolids are applied to agricultural land. See page 38 for a complete list.

Heavy metals are found in agricultural soils, occurring naturally as a result of soil deposition and development. Further additions can result from long-term atmospheric deposition and the use of commercial fertilizers.

Some metals have no agricultural value. If they're applied excessively, there's a risk of accumulation in soils and increased uptake by crops. This can have phytotoxic effects that reduce crop yield, impact crop quality, or result in further potential bioaccumulation in the food chain.

Heavy metals are often bound with other elements and not easily converted to a form suitable for uptake by crops. For this reason, crop uptake tends to be very low. The risk of heavy metal uptake increases, however, if the pH of the soil is acidic (pH <6.0).

Management Response

- ✔ Monitor levels of heavy metals: some are micronutrients needed by crops for healthy growth.
- ✔ Abide by current regulations, which require the pH of the soil to be 6.0 or greater if biosolids are to be applied.
- ✔ Abide by regulations that set out maximum heavy metal concentrations allowed in any material applied to agricultural soils, as well as maximum heavy metal additions. The regulations also prohibit biosolids application where these elements exceed a maximum concentration in the receiving soil.

Soils prone to acidity should be limed prior to receiving biosolids.

PATHOGENIC MICRO-ORGANISMS

Concerns

Many micro-organisms live naturally in the environment and are harmless to animals and humans. However, some micro-organisms can cause disease or illness if they come into contact with or are ingested by humans or other animals.

These micro-organisms are often simply referred to as "pathogens." Pathogens are tiny organisms commonly found in the digestive tract of infected humans and animals, leading to elevated levels in the feces of these individuals. This poses a potential risk of waterborne transmission.

Biosolids originate from a sewage treatment process designed to reduce pathogen levels. While the treatment process greatly reduces the presence of these micro-organisms, it does not eliminate them completely.

WWTP treatment processes are designed to eliminate over 99% of E. coli in sewage biosolids.

Management Response

✔ Deploy best management practices and standard operating procedures at the sewage treatment plant to significantly reduce pathogens

- ► pathogen reduction is a design standard for the digesters used in the treatment process.

✔ Use in-field management practices such as setback distances, pre-tillage, injection, and timely incorporation into the soil to significantly reduce the potential for micro-organisms to reach surface water or groundwater.

CONSTITUENTS FROM PHARMACEUTICALS AND PERSONAL CARE PRODUCTS

Concerns

Sewage biosolids may contain trace amounts of a wide variety of residues from:

- ► personal care products such as soaps, shampoos, and detergent
- ► the use of healthcare products (e.g., pharmaceutical residues from antibiotics, medications, and both natural and manmade hormonal compounds).

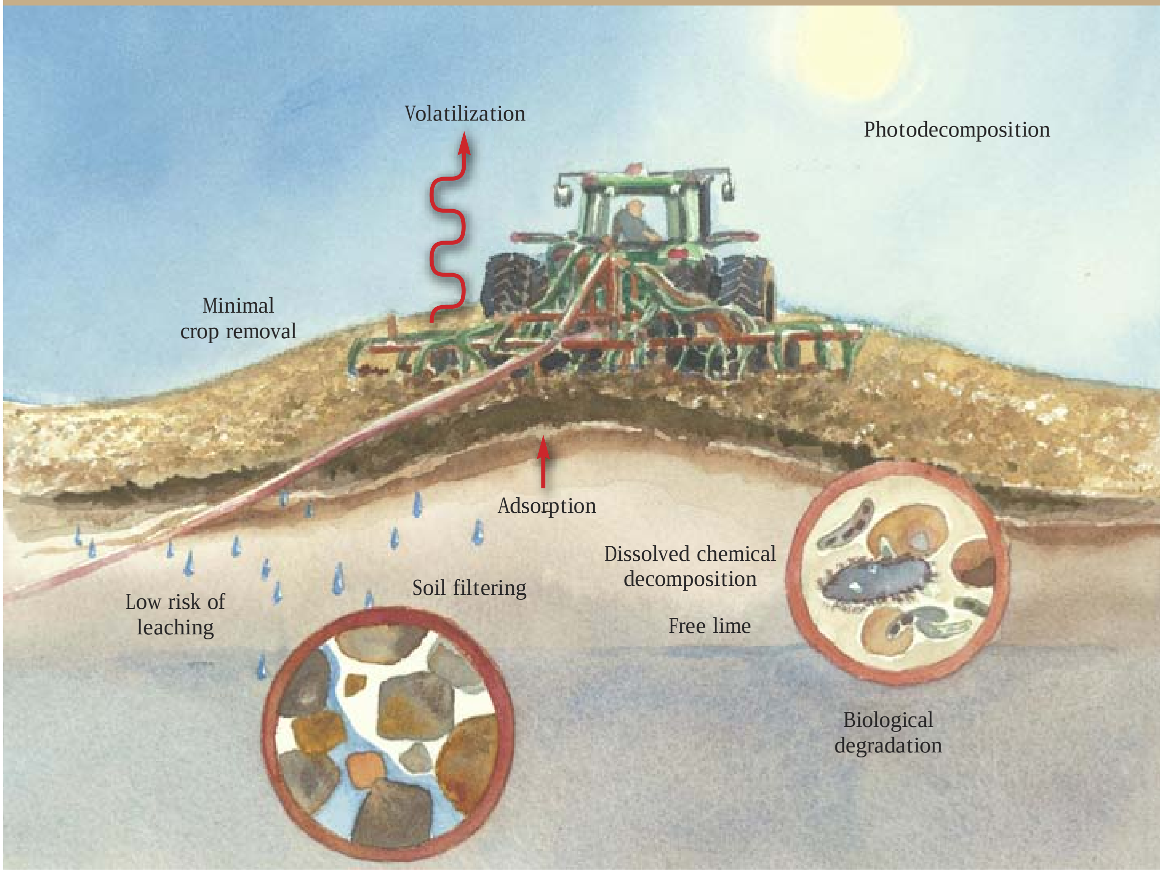
As they enter the environment, some of these residues are of concern because they are known or suspected to affect normal reproductive functions in animals such as fish.

Studies have shown consistently that many do not persist in the soil for extended periods. Also, uptake of these residues by plants is unlikely because plant roots do not absorb most pharmaceuticals and personal care products. Therefore, these residues pose a minimal risk to crop growth and human health.

Management Response

A significant amount of research is underway to examine the impacts of treatment processes on these residues and their fate and persistence after sewage biosolids are applied to agricultural land. The concentrations of these various residues and compounds in sewage biosolids are commonly only just above detection levels (i.e., parts per billion, or parts per trillion).

DECOMPOSITION OF RESIDUES BY SOIL MICROBES



Soil microbes rapidly decompose residues from the low concentrations of soaps and personal care products found in treated sewage biosolids. Soils filter chemicals out of the soil solution where they are adsorbed by soil minerals and organic matter particles. On these sites, chemicals are subjected to microbial decomposition and further chemical transformations.

Here's an example to help you understand the concentration of the various constituents in sewage biosolids and related terminology:

- **1 part per million (ppm) is equivalent to 1 second in ~ 11.6 days (0.03 years)**
- **1 part per billion (ppb) is equivalent to 1 second in 30 years**
- **1 part per trillion (ppt) is equivalent to 1 second in 30,000 years.**

OTHER ORGANIC COMPOUND RESIDUES

Concerns

Organic compounds include dioxins and furans, polychlorinated biphenyls, polyaromatic hydrocarbons, and various phenolic compounds. These compounds pose or are suspected of posing a cancer risk if ingested by humans in large enough amounts.

Organic compound residues have been found in sewage biosolids at extremely low or trace concentrations, i.e., a few parts per billion or parts per trillion. At these very low concentrations, the potential for crop uptake or bioaccumulation is minimal.

Management Response

Research indicates that many of these compounds will:

- volatilize
- be consumed by soil microbes, or
- degrade quickly within the treatment plant and in the soil after land application.

Other research shows crop uptake is minimal, because the compounds are too complex for uptake by root tissues.

Many of these compounds bind tightly to soil particles, thereby reducing the risk of off-site movement, and facilitating degradation.

Although complex organic chemicals such as dioxins and furans are a significant concern, research has consistently shown that the trace concentrations found in treated biosolids are subject to volatilization and biological degradation after land application. Moreover, plant tissue analyses indicate that crop uptake of these chemicals is minimal.

RESPONDING TO LOCAL CONCERNS

Land application of biosolids is not without controversy, as noted earlier. Most of the concerns are expressed locally. Typically, they involve one or more of the following:

- odours from biosolids
- attraction of vectors (e.g., insects, birds)
- threats to well water quality and food safety
- road traffic
- risk of damage to local public roads by the trucks used to transport biosolids.

Responding to local concerns can be the responsibility of any of the key players in a land application program for biosolids. This includes municipal staff, consultants, haulers, receivers (farmers), and provincial government staff.

The best approach to addressing concerns is proactive, not reactive. Proactive means advance work: careful site selection, proper approvals process, and prior communication with neighbours. Adapting operations to reduce nuisance impacts wherever possible can go a long way too. There is no single approach to addressing concerns. Approaches will vary, depending on stakeholder knowledge and specific concerns.

Being well-informed about the regulations in place to protect the environment can also be part of an effective response.

Careful planning, good communication, listening, and respect are key ingredients in responding effectively to local concerns.

Biosolids can have their own distinctive odour, depending on the type of treatment used. Some biosolids may have only a slightly musty, ammonia odour. Much of the odour is caused by compounds containing sulphur and ammonia, both of which are plant nutrients.

Rural residents' concerns often involve nuisances such as truck traffic and dust generated during application operations.

NUISANCES AND ODOURS

Biosolids odour does vary with treatment process and application method. Treatment can reduce odours but does not eliminate them completely. Odour control and proper application greatly reduce the presence of nuisances such as flies, birds, and rodents, which can be carriers of harmful micro-organisms.

Good site management procedures include injection of sewage biosolids into the soil, or incorporation soon after application. Increasing the setback distance to a nearby residence or residential area is also effective in minimizing potential impacts on neighbours.

Current injection technologies reduce odours dramatically.

Everyone in the biosolids industry relies on one another and the processes in place for safe and effective biosolids application. Generators who choose to have their materials land-applied must provide assurance to land applicators (and ultimately farmers) that the materials meet specifications for quality and safety. Permits and approvals are in place to ensure suitable quality, site selection and management practices – all within the overarching mandate of environmental protection. Land applicators know it's in their best interest to comply with all the regulatory requirements and use BMPs whenever possible. Farmers use their NASM plans and nutrient management BMPs to ensure their operations are receiving the appropriate nutrients for their land, when and where they need them.

WASTEWATER AND BIOSOLIDS TREATMENT

In this brief chapter, we'll explore the treatment processes that result in biosolids deemed acceptable for application on agricultural land. It all begins with wastewater.

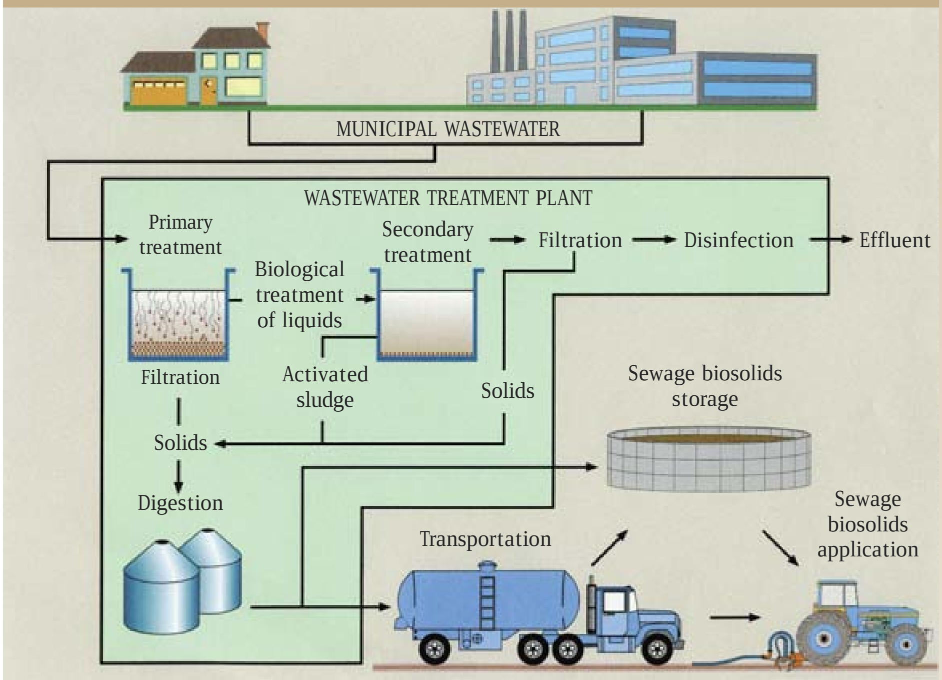
WASTEWATER TREATMENT

Before a municipality or industry can release wastewater into a river, lake or stream, it must remove a certain amount of suspended solids and other contaminants in the wastewater. Effluent discharge quality limits are specified in a Certificate of Approval. These limits must be met.

Biosolids are produced primarily through the biological treatment of domestic wastewater. They are the solids or sludge removed from wastewater before the treated water can be released into streams, lakes or rivers.

Municipal wastewater treatment results in discharged effluent and sewage biosolids.

WASTEWATER TREATMENT PROCESS

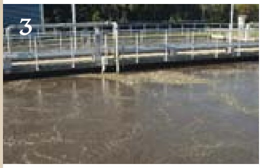


5-STEP PROCESSING

Wastewater treatment is done in five stages.

1 – Pre-Treatment
The first stage involves screening to remove coarse solids such as sticks, paper, and rags in addition to grit removal of the finer inorganic solids. This material is usually dewatered and landfilled, and does not contribute to the production of sewage biosolids.

2 – Primary Treatment
Roughly half of the remaining solids are removed by allowing solid particles to settle to the bottom of a settling structure, as floating materials are skimmed from the surface. These solids or raw sludge contribute to the production of biosolids.



3 – Secondary (Biological) Treatment
Wastewater is then subjected to secondary (i.e., biological treatment). In this stage, micro-organisms (bacteria and protozoa) consume the remaining organic matter. The microbial biomass (organic residue) is then allowed to settle and is separated from the wastewater. The microbial biomass from the secondary sedimentation stage is typically combined with raw sewage sludge from the primary stage to contribute to the production of sewage biosolids.

4 – Tertiary Treatment
Tertiary treatment for the most part involves filtration of the secondary treatment effluent to remove almost all of the remaining suspended solids. These solids also contribute to the production of biosolids.

5 – Wastewater Disinfection
Treated wastewater is disinfected to kill remaining pathogenic bacteria prior to the wastewater being discharged to a water body. Methods of disinfection include UV radiation, chlorination or ozonation.

BIOSOLIDS TREATMENT

Physical processes are most commonly used to improve biosolids quality. The raw sewage solids or sludge generated during the wastewater treatment process are digested by micro-organisms in the presence of oxygen (aerobic digestion) or without oxygen (anaerobic digestion) and varying degrees of heat.

Chemical processes such as those involving pH adjustment can also be used as a method of treatment or stabilization.

These stabilization methods reduce the number of disease-causing microbes (pathogens) in the sewage biosolids, and reduce odour potential.

Municipal sewage treatment plants use physical and biological processes to clean wastewater. One million gallons of sewage result in a ton of dry sewage biosolids or 12,000 gallons of liquid biosolids. This is equivalent to about 91–136 grams (0.2-0.3 lb) of dry solids per person per day. These solids can then be recycled on agricultural lands as sewage biosolids.

The type and extent of processes used to treat the solids will affect the degree of pathogen reduction attained and the potential for odour generation. Common treatment processes and their effects on biosolids properties and land application practices are summarized in the next chart.

BIOSOLIDS TREATMENT PROCESSES AND THE IMPACTS ON LAND APPLICATION PRACTICES

TREATMENT PROCESS AND DEFINITION	IMPACT ON BIOSOLIDS	IMPACT ON LAND APPLICATION PRACTICES
SECONDARY TREATMENT or STABILIZATION		
DIGESTION (ANAEROBIC AND AEROBIC)		
• involves biological stabilization through conversion of organic matter to carbon dioxide, water, and methane	• reduces the biodegradable content (stabilization by conversion to soluble material and gas) • reduces pathogen levels and odour	• enhances the quality of biosolids
TERTIARY TREATMENT – FURTHER PROCESSING METHODS		
DEWATERING		
• involves high-force separation of water and solids • includes methods such as vacuum filters, centrifuges, filter and belt presses, among others	• increases solids concentration by 15%–40% • lowers nitrogen and potassium concentrations • improves ease of handling	• lowers transportation costs • limits application method options • lowers nutrient dispersal potential when spread
ALKALINE STABILIZATION		
• involves stabilization through the addition of alkaline materials (e.g., lime, kiln dust)	• raises pH • decreases biological activity • reduces pathogen levels and controls odour	• immobilizes metals through high pH, as long as pH levels are maintained • raises soil pH (of typically acidic soils)
COMPOSTING		
• involves aerobic, thermophilic, and biological stabilization in a windrow, aerated, static pile or vessel	• lowers biological activity • destroys most pathogens • converts sewage biosolids to humus-like material • decreases odour concerns	• fosters excellent soil-conditioning properties • contains less plant-available nitrogen than other biosolids • enjoys greater stakeholder acceptance • enhances aesthetics
HEAT DRYING (PELLETIZATION)		
• uses heat to kill pathogens and evaporate most of the water content	• disinfects sewage biosolids • destroys most pathogens • lowers odours and biological activity	• greatly reduces sewage biosolids volume • makes for easier handling and spreading • offers potential to blend with commercial fertilizer

Dewatered biosolids are easier and less expensive to handle for land application.

Stabilized biosolids contain fewer pathogens – making them suitable for land application.

Pelletized biosolids are nearly odour-free and can be used like commercial fertilizer.

OPTIONS FOR BIOSOLIDS

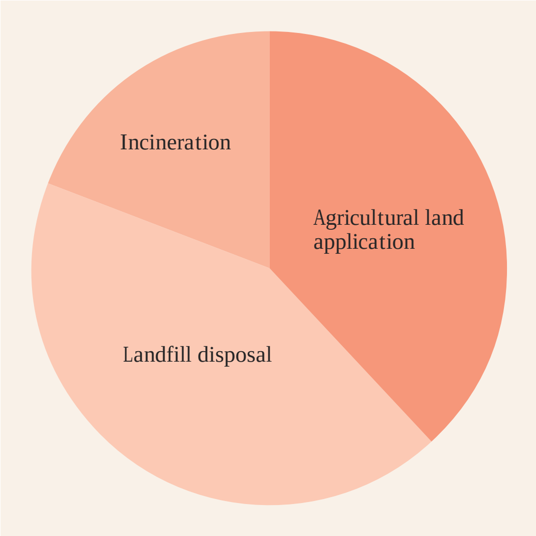
THIS CHAPTER PROVIDES AN OVERVIEW OF:

- **the options for biosolids in Ontario**
- **the regulatory requirements for each option**
- **the implications of each option.**

The most-used biosolids management options practised by Ontario municipalities are:

- ► landfill disposal
- ► incineration or energy from waste (EfW)
- ► land application.

A common option for municipalities is disposal in landfills, but this is becoming more expensive due to scarcity of available landfill capacity and more difficulty in establishing new landfills.



LANDFILL DISPOSAL

Landfill disposal offers the simplest solution by concentrating the material in a single location. The risk of release of biosolids-borne pollutants and pathogens is minimal if the landfill is properly constructed and maintained.

Sometimes biosolids must be landfilled, as in these cases:

- ► biosolids do not meet legislated quality criteria
- ► storage facilities have reached their capacity
- ► during winter, when ground is snow-covered or frozen, and application is not permitted.

Not all landfills are permitted under their Certificate of Approval to accept municipal biosolids.

There are risks with landfill disposal. Buried organic wastes undergo anaerobic decomposition, which produces methane gas. Methane is 20 times more potent than carbon dioxide as a greenhouse gas and contributor to climate change. There is also a risk of leakage from landfills. Contaminants, other chemicals, and nutrients pose a risk to groundwater resources near landfills that don't have appropriate leachate or surface water collection systems.

Another downside is the loss of potential benefits from the organic matter and plant nutrients in biosolids. This option also uses up valuable landfill space.

REGULATORY REQUIREMENTS

Licenses and approval documents are issued by the Ministry of the Environment (MOE).

Each landfill site may be subject to the requirements of the Environmental Assessment Act (EAA). Each landfill site must be approved under Part V of the Environmental Protection Act (EPA) to accept sewage biosolids.

Sewage biosolids must be hauled from the sewage treatment plant to the landfill site by vehicles licensed under the EPA for this purpose.

Biosolids must be managed at the landfill site in accordance with the Certificate of Approval for the site as issued under the EPA.

In some municipalities, biosolids don't qualify for land application because of the concentration of metals in the biosolids.

INCINERATION OR ENERGY from WASTE (EfW)

Incineration reduces the biosolids volume, kills pathogens, destroys most organic chemicals, and may provide energy.

Incineration is one of the more expensive options for biosolids disposal, because it requires sophisticated systems to remove fine particulate matter (fly ash) and volatile pollutants from stack gases.

The incinerator ash is a stable, relatively inert, inorganic material that possesses 10–20% of the original volume. Trace elements are not destroyed during incineration, which increases their concentrations substantially. The ash containing the higher trace element concentrations is usually landfilled.

Incineration releases carbon dioxide (a greenhouse gas).

As with landfilling, the potential benefits of organic matter and nutrient utilization are lost.

The option of incineration reduces the net volume of biosolids – but misses the opportunity to return nutrients to cropland.

REGULATORY REQUIREMENTS

Incinerators, whether private or municipally operated, must be established and operated under a Certificate of Approval issued by MOE. Also:

- incinerators are subject to the requirements of the EAA
- there are strict controls on the air emissions from incineration that must be met by the owner/operator
- the incinerator ash generated must be disposed of in an environmentally acceptable manner – strict environmental quality standards must be met for the final disposal of incinerator ash at a disposal (landfill) facility approved under the EPA.

FURTHER PROCESSING

Some larger wastewater treatment plants also treat biosolids by dewatering, lime stabilization, or pelletization.

This further treatment results in lower transportation costs, other marketing opportunities, and in some cases a reduction in pathogens. Sometimes the material is sold as a commercial fertilizer and regulated under the federal Fertilizers Act.

Composting is another option but is not commonly done in Ontario due to strict regulatory requirements on the regulated metal content of the feedstock materials used.

Mid-size to large composting facilities are suited for further processing of dewatered biosolids.

AGRICULTURAL LAND APPLICATION

Although sewage biosolids can be used in land reclamation and forest management, the majority of land application is to agricultural land. This is considered beneficial use rather than another form of disposal. It recycles valuable nutrients and organic matter, doesn't put further demand on waste disposal facilities, and when properly managed is environmentally friendly.

REGULATORY REQUIREMENTS

There are strict rules governing the land application of sewage biosolids in Ontario.

MOE and the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) govern this activity by setting and enforcing criteria for the land application of sewage biosolids in Ontario. The regulations and protocols make possible the use of biosolids and other non-agricultural source materials (NASMs) on agricultural land, while protecting environmental quality, consumer and animal health, food quality, and the land's productivity.

The regulations and protocols outline criteria that must be met before biosolids can be considered for use on cropland. Biosolids supply essential plant nutrients and/or organic matter, or other constituents that will maintain crop production or soil health. Before OMAFRA will grant approval, it must be demonstrated that management of the biosolids will not degrade the natural environment.

"The application of biosolids is considered beneficial by most producers. There isn't nearly enough livestock manure to improve soil conditions. Biosolids are a reliable alternative."

Harry Buurma, WEAO/BUC Biosolids Forum, 2008, Barrie

LAND APPLICATION – SOCIETAL ASSURANCE THROUGH SAFETY AND PROFESSIONALISM

Science, compliance monitoring, and enforcement combine to reduce the risk of land application of biosolids.

Sites must be assessed to determine their suitability for application.

Increases in metal concentrations in soils receiving biosolids can be limited with analyses and quality control, and frequency of application and application rates.

A farmer's NASM plan:

- generates options for appropriate application rates, method and timing of application
- determines nutrient application rates by assessing crop needs, site limitations, and existing soil nutrient levels
- sets liquid loading limits to reduce the risk of runoff, and
- establishes separation distances from sensitive features such as surface water.

Site operations are monitored by the landowner or land application representative.

Records must be kept regarding the operation, application rates, application method, weather, and site conditions, etc.

The application procedure must abide by regulated separation distances from residences, wells and surface waters.

Throughout the land application process, record-keeping is essential for effective quality control.

BIOSOLIDS CHARACTERISTICS AFFECTING LAND APPLICATION

THIS CHAPTER EXPLORES:

- **what's in biosolids**
- **the implications of the quality of biosolids on application, soil, and human health.**

Biosolids have physical, chemical and biological properties that affect:

- management or disposal options
- land application practices
- the nature and extent of environmental risk (e.g., loss of crop nutrients to the environment).

Biosolids are analyzed for these properties to determine their suitability for land application. Biosolids analyses also provide essential information for effective nutrient management practices.

TYPES AND PROPERTIES

Biosolids composition is directly related to the nature of the wastewater constituents and treatment processes. The resulting properties will determine suitability for application – and if suitable, the application method and rate.

CHARACTERISTICS OF THREE TYPES OF SEWAGE BIOSOLIDS

BIOSOLIDS TYPE	AEROBICALLY DIGESTED LIQUID	ANAEROBICALLY DIGESTED LIQUID	DEWATERED
TOTAL SOLIDS	1–2.4%	1.7–7.0%	18–40%
TOTAL NITROGEN	1.6–6.1% ***	2.8–9.0%	3.1–7.0%
AMMONIUM–NITROGEN	100–7,000 mg/kg	3,300–34,000 mg/kg	3,500–6,800 mg/kg
FERTILIZER EQUIVALENT NITROGEN*	Trace – 0.6 kg/m^3 Trace – 6 lb/1,000 gal	0.2–1.9 kg/m^3 2–19 lb/1,000 gal	2.4–7.2 kg/tonne 4.8–14.4 lbs/ton (wet weight)
TOTAL PHOSPHORUS	1.8–4.0%	1.5–6.3%	2.2–4.5%
FERTILIZER-EQUIVALENT PHOSPHORUS AS P_2O_5 **	0.2–0.9 kg/m^3 2–9 lb/1,000 gal	0.2–2.6 kg/m^3 2–26 lb/1,000 gal	4.5–12.4 kg/tonne 9–24.8 lbs/ton (wet weight)

* Fertilizer-equivalent nitrogen equals ammonium–nitrogen plus 30% of the organic nitrogen.
** Fertilizer-equivalent phosphorus equals 40% of the total phosphorus expressed as P_2O_5.
*** Values are expressed on a dry weight basis (i.e., % dw or mg/kg of total solids) unless otherwise indicated.

Dewatered biosolids can contain up to 40% solids, allowing them to be handled like solid manure.

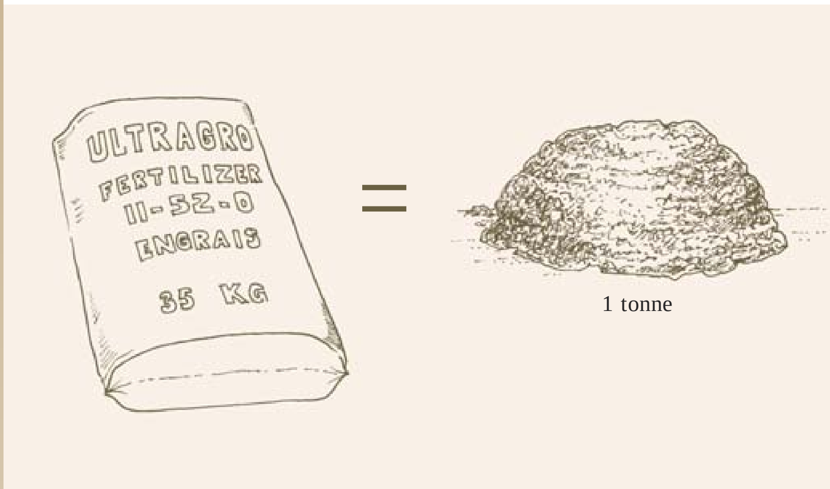
Anaerobic liquid biosolids have slightly lower levels of organic matter and nutrients than aerobic liquid biosolids.

Biosolids are analyzed to determine suitability for land application.

KEY PROPERTIES ASSESSED BY BIOSOLIDS ANALYSES

PROPERTY	DETAILS	TYPICAL LEVELS
TOTAL SOLIDS (TS)	• suspended and dissolved solids are expressed as the concentration present in biosolids • TS depend on the type of wastewater process and biosolids treatment prior to land application	• solids contents of various biosolids processes are: liquid (1–7%), dewatered (18–40%), and dried or composted (50–95%)
pH	• pH is a measure of the degree of acidity or alkalinity of a substance • the pH of biosolids can be raised with alkaline materials to reduce pathogen content and attraction of disease-spreading organisms (vectors)	• alkaline treatment of biosolids results in a high pH (greater than 11) that kills most micro-organisms and reduces the solubility, biological availability, and mobility of most metals • lime also increases the gaseous loss (volatilization) of the ammonia form of nitrogen (N), thus reducing the N-fertilizer value of biosolids and creating the potential for additional odour generation during treatment with lime
MICRO-ORGANISMS – BACTERIAL INDICATORS OF PATHOGENS	• pathogens are disease-causing micro-organisms that include bacteria, viruses, protozoa, and parasitic worms • pathogens can present a public health hazard if: ○ transferred to food crops grown on land to which biosolids are applied ○ contained in runoff to surface waters from land application sites, or ○ transported away from the site by vectors such as insects, rodents, and birds	• regulations specify pathogen and vector-attraction reduction requirements that must be met before biosolids can be applied to land • for a partial list of pathogens that may be found in **untreated** sewage and the diseases or symptoms that they can cause, see page 43
NUTRIENTS	• nutrients are elements required for plant growth	• these include nitrogen (N), phosphorus (P) and potassium (K)* • additional nutrients found in sewage biosolids include calcium (Ca), magnesium (Mg), sodium (Na), sulphur (S), boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn) • concentrations in biosolids can vary significantly – the actual material being considered for land application must be analyzed
TRACE ELEMENTS	• trace elements are found in low concentrations in biosolids • the trace elements of interest in biosolids are those commonly referred to as "heavy metals" • some of these trace elements (e.g., copper, molybdenum, and zinc) are nutrients needed for plant growth in low concentrations, but all of these elements can be toxic to humans, animals, or plants at high concentrations	• possible hazards associated with a buildup of trace elements in the soil include their potential to cause phytotoxicity (i.e., injury to plants) or to increase the concentration of potentially hazardous substances in the food chain • provincial regulations have established standards for 11 trace elements: arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), cobalt (Co), chromium (Cr), and zinc (Zn)

* K may be present in low concentrations in some sewage biosolids, depending on treatment process.



One tonne of dewatered biosolids is approximately equivalent to the amount of nutrients found in 35 kg of mono-ammonium phosphate (MAP) (11-52-0).

NUTRIENTS IN BIOSOLIDS

PLANT NUTRIENTS

Like applying livestock manure to cropland, land-applying biosolids is a way of utilizing organic forms of plant nutrients. Biosolids contain many nutrients needed for plant growth including nitrogen, phosphorus, zinc, and copper. The amounts of nutrients in sewage biosolids vary from source to source, based on treatment process, origin, types, and the volume of wastewaters treated.

Nutrients in biosolids are not as concentrated as in commercial fertilizer. Nitrogen (N) and phosphorus (P) levels in biosolids are about one-quarter to one-fifth of those found in typical blended fertilizers. It would take much larger application rates of sewage biosolids to match the nutrient content of commercial blended fertilizer.

Nitrogen in biosolids tends to release slowly. Because of the slow release, plants can use the nitrogen in biosolids more efficiently over time than the nitrogen in a single application of fertilizer.

Moreover, much of the N and P in sewage biosolids is in the organic form and is not readily available to plants. When applied to land, part of the organic nitrogen is mineralized or converted into ammonium (NH_4^+), nitrate (NO_3^-), or both to become available to plants over time.

Some nitrogen in the biosolids may be lost to the air – especially if left at the surface – due to ammonia volatilization. If biosolids have an ammonia-like odour, some nitrogen is being lost. To reduce the amount of nitrogen lost, biosolids can be injected or incorporated into the soil directly after application. Incorporation also reduces any potential for odour problems sometimes associated with land application of biosolids.

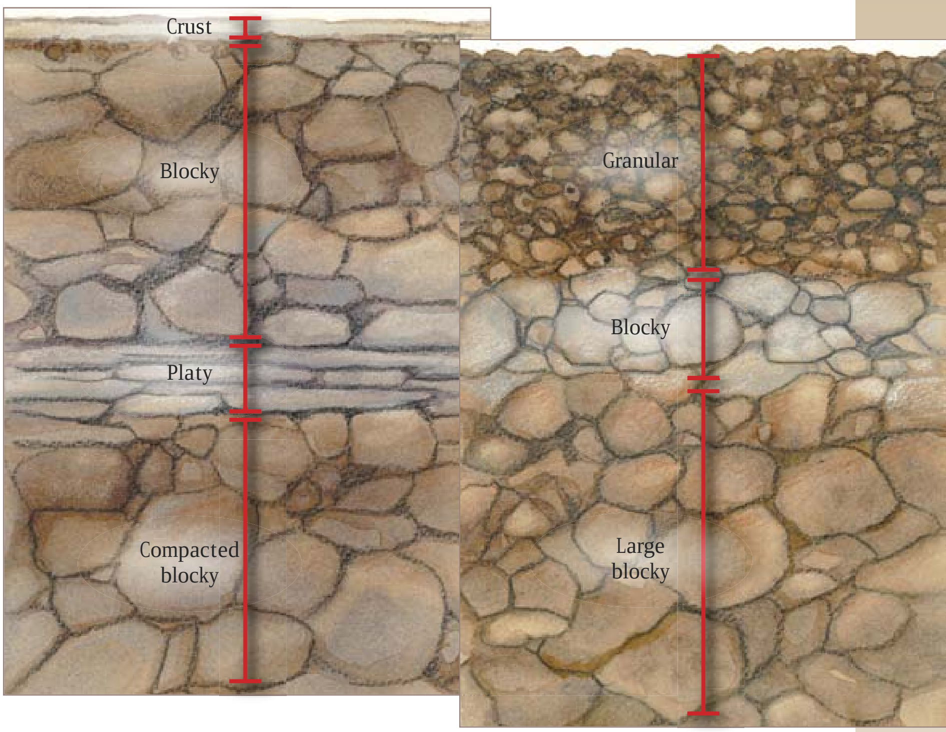
Most sewage biosolids are low in potassium (K), and this nutrient may need to be added as a supplement to the biosolids.

ORGANIC MATTER

Organic matter from applied biosolids improves soil structure and the workability (tilth) of most soils.

In sandy soil, organic matter increases the soil's ability to hold water. In clayey soil, organic matter opens up the soil to allow better air and water movement into and through the soil. Organic matter also improves water retention, permits easier root penetration, and reduces water runoff and soil erosion.

Cropland requires regular additions of organic matter to improve soil quality. The soil profile on the left has not received regular additions of organic matter: note the poor seedbed structure. The soil on the right demonstrates how additions of organic matter result in improved seedbed structure, root exploitation, and available moisture.



Poor soil condition can be improved with regular applications of biosolids, as seen in the soil on the right.

APPLICATION RATES

In order to balance nutrient use efficiency with environmental protection, biosolids application is limited to the agronomic rate.

Nitrogen

The agronomic rate for nitrogen is defined as the amount of biosolids that provides the amount of nitrogen needed by the crop, or whatever plants are grown on the land – while minimizing the amount of nitrogen that is unused and could potentially leach below the root zone and into groundwater.

In addition to the crop's nutrient requirements, one of the key determinants of agronomic rate is the estimation of available nitrogen. Nitrogen from biosolids has two forms: organic and inorganic.

Organic nitrogen refers to any nitrogen tied up in material that either is or used to be alive, such as plant material.

Inorganic nitrogen refers to nitrogen in the mineral form, such as ammonium-nitrogen and nitrate-nitrogen. Inorganic nitrogen is immediately available for crop uptake.

Determining the Nitrogen Contribution from Applied Sewage Biosolids

The amount of nitrogen from an application of sewage biosolids that's available to the crop being grown is called "plant-available nitrogen" or PAN.

Once it's applied to land, organic and inorganic nitrogen each has characteristics that can influence the amount of nitrogen that will be available for a crop to use.

- organic nitrogen
  - organic matter degrades slowly over time
  - following land application, a portion of the organic nitrogen is mineralized, or converted to an inorganic form
  - only a portion of the organic nitrogen can be counted as PAN

- inorganic nitrogen
  - most of the inorganic nitrogen is in the form of ammonium and ammonia
  - the remainder of the inorganic nitrogen is in the form of nitrate and nitrite
  - all of the inorganic nitrogen is considered PAN

The following step-by-step example illustrates the nitrogen availability calculation for aerobically digested sewage biosolids.

The laboratory analysis reports the following nitrogen concentrations on a dry weight basis:

- 5.75% Total Kjeldhal Nitrogen (TKN)
- 0.8% ammonium-nitrogen
- 0.5% nitrate-nitrogen.

The sewage biosolids in this example will be surface-spread, then immediately incorporated.

Step 1. Contribution of Nitrogen from the Organic Fraction of Biosolids
The rate at which organic N becomes PAN can change from material to material. The following table provides an estimate of how much PAN will be supplied by an application of different sources of sewage biosolids.

ESTIMATES OF ORGANIC NITROGEN MINERALIZATION RATES FOR VARIOUS SEWAGE BIOSOLIDS

TREATMENT PROCESS	MINERALIZATION FACTOR (MF)
ALKALINE STABILIZED	0.3
AEROBICALLY DIGESTED	0.3
ANAEROBICALLY DIGESTED	0.3
COMPOSTED	0.1

Sewage biosolids analysis results for nitrogen are usually reported as TKN. TKN estimates **all** of the nitrogen contained in a material, regardless of the form that it is in. Therefore, to determine the level of organic N, the inorganic fraction (ammonium-nitrogen + nitrate-nitrogen concentrations) must be subtracted from TKN.

Organic nitrogen = TKN − (ammonium-nitrogen + nitrate-nitrogen)
Organic nitrogen = 5.75% − (0.8% + 0.5%)
Organic nitrogen = 4.45%

Next, the organic nitrogen content is multiplied by the mineralization factor to obtain the contribution of organic nitrogen to the PAN. The amount of PAN from the organic fraction is:

% PAN from organic nitrogen = % organic nitrogen × mineralization factor
% PAN from organic nitrogen = 4.45% × 0.3
% PAN from organic nitrogen = 1.335%

Step 2. Contribution of Nitrogen from the Inorganic Fraction of Biosolids
Ammonium-nitrogen and nitrate-nitrogen content of sewage biosolids does not have to be calculated. It can be read directly from the analysis. Portions of this inorganic fraction can, however, be lost.

Ammonium-Nitrogen

Ammonium-nitrogen is subject to loss by volatilization. Ammonia losses decrease the amount of PAN in the soil. Obviously, plants can only use the nitrogen retained in the soil. Losses are greater for material left on the surface of the soil. Injection or immediate incorporation below the soil surface reduces losses. Actual losses of ammonium-nitrogen vary with weather and soil conditions, but the amount of nitrogen retained in the soil can be estimated using the simplified table below.

ESTIMATES OF RETAINED AMMONIUM-NITROGEN FOR THREE METHODS OF APPLICATION

APPLICATION METHOD	AMMONIA RETENTION FACTOR
SURFACE SPREADING	0.50
SURFACE SPREADING FOLLOWED BY INCORPORATION (within 24 hours)	0.75
SUBSURFACE INJECTION	1.00

To calculate the amount of ammonium-nitrogen retained in the soil, the ammonium-nitrogen concentration is multiplied by the ammonia retention factor to obtain the percentage of ammonium that will be PAN. For our example, the material is incorporated within 24 hours; therefore, the ammonia retention factor is 0.75.

Retained ammonium PAN = Ammonium-nitrogen concentration × retention factor
Retained ammonium PAN = 0.8% × 0.75
Retained ammonium PAN = 0.6%

Nitrate-Nitrogen

Small amounts of nitrate-nitrogen, another inorganic form of nitrogen, are present in biosolids. All of the nitrate-nitrogen is considered PAN.

Nitrate PAN = 0.5%

Step 3. Total Nitrogen Contribution from Sewage Biosolids
Total % PAN = Organic PAN + Ammonium PAN + Nitrate PAN
Total % PAN = 1.335% + 0.6% + 0.5%
Total % PAN = 2.435%

This PAN value can now be used in determining the appropriate application rate to meet the N requirements of the crop to be grown. If the material were to be applied at 8,000 kg of dry matter per hectare, the total PAN contribution from this application would be approximately 195 kg per hectare.

8000 kg/ha × 2.435% PAN = 194.8 kg/ha PAN

Because nitrogen can leach down through the soil below the root zone of the crop and possibly into groundwater, care should be taken to ensure that nitrogen applications are closely matched to crop requirements to limit the amount of nitrogen available for loss through leaching.

The effects of biosolids on soil physical properties (such as increased soil aggregate formation and aggregate stability) may be greater than animal manure due to the stability of organic compounds in biosolids.

Phosphorus

Some phosphorus in biosolids becomes crop-available during the year of application. In fact, it's estimated that 40% of the total phosphorus in biosolids becomes plant-available in the year of application. It's thought that another 40% becomes available during subsequent years.

Nutrient management planning is needed to avoid excessive buildup of soil phosphorus, which increases potential for phosphorus loss in runoff and erosion, and contamination of surface waters.

Soils should be tested after three to four years to ensure adequate phosphorus availability and to avoid excessive soil phosphorus levels.

Potassium

Biosolids don't supply much potassium. Potassium is soluble and most of this element stays in the liquid fraction of the treated wastewater. Additional sources of potassium might be required to meet agronomic crop requirements.

CHEMICAL PROPERTIES OF BIOSOLIDS

The characteristics of both the biosolids and the application site can influence the quantity of biosolids applied and the application method.

Some heavy metals, including zinc and copper, are micronutrients that are necessary for plant growth. Excessive amounts of some heavy metals (zinc, copper, nickel) can be damaging to plants, resulting in reduced yield or even plant death.

In addition to crop nutrients, biosolids quality criteria address pathogen levels and concentrations of chemical contaminants.

In order to be land-applied, all biosolids must:

- be treated to reduce pathogen levels (see page 42)
- not exceed the maximum allowable concentration limit for each of the regulated metals listed in the following chart.

The total amount of the regulated metal applied to a piece of land over time cannot exceed the standard for cumulative loading. Pre-harvest and pre-grazing waiting periods are an added precaution.

REGULATED METAL STANDARDS IN SEWAGE BIOSOLIDS APPLIED TO LAND

REGULATED METALS	MAXIMUM PERMISSIBLE METAL CONCENTRATION IN BIOSOLIDS	MAXIMUM METAL ADDITION TO SOIL	MAXIMUM METAL CONCENTRATION IN SOIL*
	mg/kg of total solids dry weight	kg/ha/5 years	mg/kg of soil, dry weight
ARSENIC	170	1.40	14
CADMIUM	34	0.27	1.6
COBALT	340	2.70	20
CHROMIUM	2,800	23.30	120
COPPER	1,700	13.60	100
MERCURY	11	0.09	0.5
MOLYBDENUM	94	0.80	4
NICKEL	420	3.56	32
LEAD	1,100	9.00	60
SELENIUM	34	0.27	1.6
ZINC	4,200	33.00	220

* in soil prior to receiving sewage biosolids

Remember that all of these metals are naturally occurring in all soil. Sewage biosolids exceeding these standards or concentrations cannot be land-applied.

The following table summarizes the potential health effects of micro-constituents in sewage biosolids.

POTENTIAL CHEMICAL CONTAMINANTS IN SEWAGE BIOSOLIDS AND WAYS TO MANAGE THEM

CONTAMINANT	POTENTIAL CONCERN	SOLUTION
HEAVY METALS		
COPPER, ZINC, NICKEL	• accumulate in topsoil • are toxic to plants at high levels	✔ reduce source of metal in sewage biosolids ✔ apply according to soil-loading limits ✔ adjust soil pH to a value greater than 6.0
CADMIUM	• accumulates in topsoil • taken up by plant and accumulates in leafy material • accumulates in animal organs • linked to human health problems	✔ reduce source of metal in sewage biosolids ✔ apply according to soil-loading limits ✔ adjust soil to greater than pH 6.0
LEAD	• accumulates in topsoil • can be harmful if excessive amounts are ingested with soil particles by animals	✔ reduce source of metal in sewage biosolids ✔ apply according to soil-loading limits ✔ adjust soil to greater than pH 6.0
MERCURY, CHROMIUM, SELENIUM, ARSENIC	• typically present in low concentrations and therefore of little concern	
ORGANICS		
CHLORINATED HYDROCARBON PESTICIDES, POLYCHLORINATED BYPHENOLS (PCBs), ETC.	• present a health hazard if directly ingested by animals • typically present in low concentrations (ppt or ppb) and therefore of little concern	✔ inject or disk into soil – most are biodegradable

BIOSOLIDS CHARACTERISTICS LIMITING APPLICATION RATE

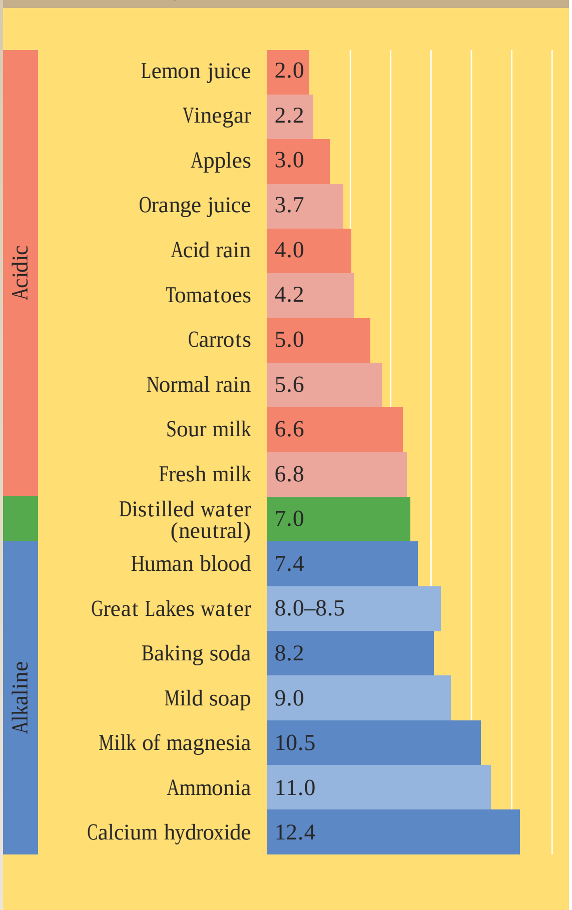
Metals

At one time, wastewater treatment plants in highly industrialized urban centres – especially those with metal-plating factories – produced sewage biosolids with high concentrations of metals. Sewer use bylaws and other wastewater source management initiatives have been used to drastically reduce these concentrations. Biosolids currently produced by most municipalities have metal concentrations substantially lower than the maximum permissible concentrations.

Materials discharged to municipal sewage collection systems are monitored to ensure they meet local sewer use bylaw limits.

If the metal concentrations in sewage biosolids applied to agricultural land were at the maximum permissible concentrations, it would take approximately 25 to 55 years for a typical Ontario soil to reach the maximum recommended limits set in these standards. However, since the metal concentrations in biosolids are continuing to be reduced, applications may be allowed to continue for a longer period of time.

THE pH OF COMMON LIQUIDS



pH

The pH of biosolids applied to a living crop should be in the 6.0 to 8.5 range. Materials with pH levels outside of this range should be applied to cropland only when crop damage will not be an issue, such as before planting or after harvest, or prior to ploughdown. Care should be taken when applying lime-stabilized biosolids with a high pH to avoid crop damage.

In some cases, analytical information about other elements may be requested to help the applicant and the Ministry assess the suitability of a particular biosolids for land application. The applicant will be required to provide appropriate analytical documentation upon request.

Industrial Organic Contaminants

Industrial organic contaminants such as organic acids, solvents, and complex compounds can have adverse health effects on humans and the environment. These compounds may be found in industrial wastewater discharged to municipal wastewater collection systems.

Research indicates that many of these compounds either volatilize or degrade quickly within the treatment plant and in the soil after land application. Other research shows crop uptake is minimal as these constituents are not generally taken up by crops.

As experience is gained and research reviewed, standards may be established for:

- maximum permitted concentrations of industrial organic contaminants in materials approved for land application
- application-rate limits based on the concentration of these contaminants, limits that continue to be protective of human and animal health and the environment.

Non-Biodegradable Constituents

Biosolids should not contain foreign non-biodegradable material such as plastics, glass and/or pieces of metal that may cause human or animal injury or damage to equipment. Check the regulatory standards for specifications.

ARE FIRE RETARDANTS IN SEWAGE BIOSOLIDS?

Yes. Fire retardants are ubiquitous in the environment – present in outdoor and indoor air, both in urban cities and rural farming communities. Fire retardants are not manufactured in Canada, but they are used in many common household products such as carpets, upholstery fabrics, clothes, computers, appliances and televisions.

A Health Canada report indicated that air (outdoor and indoor) is the major source of fire retardants for human exposure. It has been proposed by scientists that indoor air and dust pose the greatest risk to human health from fire retardants. Indoor air has been found to contain 15 to 50 times higher concentrations of fire retardants than outdoor air.

ARE OTHER INDUSTRIAL / HOUSEHOLD CHEMICALS, SUCH AS DIOXINS, PCBS, PHARMACEUTICALS AND DETERGENTS, IN SEWAGE BIOSOLIDS?

Yes, there are trace concentrations of these chemicals in sewage biosolids. However, the presence of a chemical does not equate to a risk. Risk depends on the concentration of the chemical present, the properties of the compound such as toxicity, and how the chemical will move from the biosolids to the receiving environment.

The Ontario Ministry of the Environment, the U.S. government, and the European Union have done substantial research and risk assessment on the presence of industrial chemicals, including dioxins, PCBs, pharmaceuticals, and detergents, in sewage biosolids. Their conclusion to date is that sewage biosolids are safe to be used as a fertilizer on agricultural land as long as government standards for their application are followed. Some of the reasons for such conclusions are:

- these chemicals are present at very low concentrations in sewage biosolids (ppb or ppt)
- sewage biosolids are applied at controlled and low rates to agricultural land based on an approved NASM plan
- some chemicals, e.g., detergents, break down rapidly in the environment – within a few days to a few months.

A study by the Ontario Ministry of Agriculture, Food and Rural Affairs found no difference in dioxin concentrations in soils that had received up to three applications of sewage biosolids and soils that had not received any sewage biosolids.

PATHOGEN REDUCTION

The upper table on page 43 shows some typical ranges of micro-organisms in biosolids and background levels in non-amended soils. For example, the total aerobic (oxygen-requiring) and anaerobic (organisms that cannot grow in the presence of oxygen) bacterial numbers can be almost as high in nutrient-rich soil as they are in biosolids.

Over 150 enteric pathogens have been found in raw human sewage. Enteric pathogens grow in the gut of infected individuals and can be shed in the feces in high numbers, potentially causing food and waterborne disease.

Examples of pathogens of concern in raw sewage are presented in the lower table on page 43. The types of pathogens and their concentration in raw sewage fluctuate dramatically over time, depending on the level of endemic illness in the population served by the waste treatment plant. The wastewater treatment process destroys most of these pathogens, reducing their numbers to levels that are acceptable for land application.

TYPICAL RANGES OF MICRO-ORGANISMS IN SOILS AND BIOSOLIDS

MICROBE	SOIL	BIOSOLIDS
	COLONY-FORMING UNITS PER GRAM OF DRY SOLIDS	
TOTAL AEROBIC BACTERIA	10^5–10^8	10^8–10^{10}
TOTAL ANAEROBIC BACTERIA	10^5–10^8	10^8–10^{11}
E. COLI	BD*–10^3	10^4–10^6

* Denotes "below detection."

PARTIAL LIST OF POTENTIAL PATHOGENS IN RAW MUNICIPAL SEWAGE

PATHOGEN	DISEASE AND SYMPTOMS
BACTERIA	
Salmonella spp.	salmonellosis (food poisoning)
Shigella spp.	shigellosis (bacillary dysentery), severe gastroenteritis
Campylobacter jejuni	gastroenteritis (diarrhea, vomiting, nausea, fever, etc.)
Pathogenic E. coli	gastroenteritis
VIRUSES	
Hepatitis A virus	infectious hepatitis
Rotavirus	acute gastroenteritis with severe diarrhea
Norovirus	gastroenteritis with severe diarrhea
PROTOZOA	
Giardia lamblia	giardiasis: diarrhea and abdominal cramps
Cryptosporidium spp.	cryptosporidiosis: gastroenteritis
PARASITIC WORMS	
Ascaris lumbricoides (roundworm or Helminth)	ascariasis: abdominal pain and digestive disturbances
Trichuris spp. (whipworm)	trichuriasis: cramping and diarrhea, anemia, weight loss

Wastewater treatment processes, from the initial aerobic treatment step to final sludge digestion, all contribute to significantly reduce pathogens in sewage biosolids when the treatment plant is operating properly. Biosolids treatment can achieve a pathogen reduction of 90 to 99.9%, depending on the pathogen, and typically over 99% reduction in the fecal indicator organism, E. coli.

After sludge treatment, there may still be pathogens present in the biosolids. However, if land application of biosolids is regulated and controlled, the potential risk of exposure to crops, livestock and humans will be minimized. Appropriate management will also limit the movement of pathogens to surface water and groundwater after land application.

The survival of pathogens in soil and on plants varies widely, from days to months. Their survival depends on several factors, including temperature, exposure to sunlight, and moisture levels.

Restrictions in the Nutrient Management Act, 2002 and Ontario Regulation 267/03 provide protection measures against exposure to humans, animals and the environment. These include required separation distances, loading limits, and pre-grazing and pre-harvest wait times, all of which promote natural pathogen decay in soil and sunlight with time.

RISK OF VECTOR ATTRACTION

Vectors such as rodents, birds and insects can spread pathogens from application sites to surrounding areas. The goal is to reduce the biosolids' attractiveness to possible vectors. Here are two general approaches:

- reducing the attractiveness of the biosolids to vectors with specified organic matter decomposition and stabilization processes (e.g., digestion, alkaline addition)
- preventing vectors from coming into contact with the biosolids (e.g., biosolids injection or incorporation below the soil surface within specified time periods).

BMPs FOR SEWAGE BIOSOLIDS

THIS CHAPTER SETS OUT BMPs FOR:

- **storage at treatment plants and in-field**
- **hauling and handling**
- **contingency planning**
- **application methods and equipment**
- **site criteria, including slope, soil characteristics, drainage, and distance to water bodies.**

For land-applied sewage biosolids, best management practices begin with storage and end in the field.

STORAGE

WASTEWATER TREATMENT PLANTS

Storage facilities are required to hold biosolids during periods of inclement weather, equipment breakdown, frozen or snow-covered ground, and when land is unavailable during the growing season.

Liquid biosolids can be stored in digesters, tanks, lagoons, or drying beds. Dewatered biosolids can be stockpiled. It is a BMP to have enough storage capacity to store the amount of sewage biosolids that would be produced over a 240-day period.

Sewage biosolids can only be stored in specially designed, permitted, and approved storage facilities.

Wastewater treatment plants have designated storages for biosolids destined for land application.

BIOSOLIDS ODOUR CATEGORIES

Ontario Regulation 267/03 and the associated Odour Guide set out an odour categorization system for all NASM. The odour categories are OC1, OC2 and OC3. Sewage biosolids are categorized as:

- ► OC1 – liquid, anaerobically digested sewage biosolids from a municipal sewage treatment plant or its off-site storage facility
- ► OC2 – liquid, aerobically digested sewage biosolids from a municipal sewage treatment plant or its off-site storage, and sewage biosolids that have been dewatered by means other than a centrifuge operated at less than 2,000 revolutions per minute (rpm) and stored less than 30 days after dewatering is completed
- ► OC3 – sewage biosolids that have been dewatered by a centrifuge operated at less than 2,000 rpm, or sewage biosolids that have been dewatered and stored less than 30 days after the dewatering process is completed.

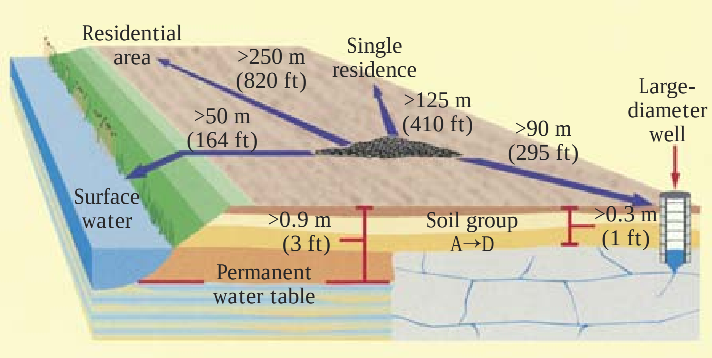
TEMPORARY IN-FIELD STORAGE

Temporary in-field storage sites may be used for dewatered municipal sewage biosolids. The amount of dewatered municipal sewage biosolids stored at the temporary site should not exceed the quantity needed for crop production on that farm unit, as outlined in the NASM plan. The maximum length of time that dewatered municipal sewage biosolids that are OC2 can be kept in a temporary in-field storage is 10 days from the time that the first load is delivered. If the biosolids are categorized as OC3, then they must be land-applied and incorporated the same day they are received at the application site.

When determining the location of a temporary site for dewatered municipal sewage biosolids, the site should have the following features:

- slope less than 3% unless the soil depth is at least 0.9 metre (3 ft) to bedrock
- Hydrological Soil Group A–D – Group A soils must have a depth of soil that is at least 0.9 metres to bedrock
- not located in a regional or 1 in 100-year flood plain
- at least 0.3 metre (1 ft) of soil above the bedrock and at least 0.9 metre (3 ft) of unsaturated soil above the permanent water table
- a flow path that is at least 50 metres (164 ft) from the nearest surface water and is located at least 0.3 metre (1 ft) above bedrock
- at least 45 metres (148 ft) from a drilled well having a depth of at least 15 metres (49 ft) and a watertight casing extending to a depth of at least 6 metres below ground level, 90 metres (295 ft) from any other well except a municipal well, and at least 100 metres (330 ft) from a municipal well
- at least 125 metres (410 ft) from a single residence and 250 metres (820 ft) from a residential area if the biosolids are OC1
- at least 200 metres (656 ft) from a single residence and 450 metres (1,476 ft) from a residential area if the biosolids are OC2.

Keep records of the location and dates of pile establishment, turning and removal.



Temporary storage sites for dewatered biosolids must be selected carefully to reduce the risk of contaminating groundwater and surface water.

HAULING AND HANDLING

Successful hauling and handling is:

- practical
- conducted with public safety and acceptability in mind
- in adherence with all provincial regulations and local bylaws
- environmentally sound.

The method of transport and subsequent application depends on many factors. Considerations include:

- the characteristics and quantity of sewage biosolids to be transported
- distance to the application site
- costs of transport and application method.

The final plan for hauling for land application is a mutual decision made by the municipality and the broker. It is usually outlined in a written agreement.

While a municipality may operate its own land application program, most municipalities hire experienced contractors to handle their sewage biosolids land application program.

Critical components of a hauling and handling program include:

- transport method – type and quantity of materials to handle
- contractor and staff education on the safe handling of biosolids
- timing of transportation to coincide with periods of low traffic volume, if possible
- proper signage and safety practices
- distances and routes
- number and capacity of vehicles
- vehicle maintenance and sanitation
- suitable transfer sites
- contingency plans including:
  - contingency measures for spills
  - alternative delivery locations.

Most municipalities use highway transports to haul biosolids to the application site.

Biosolids are often transferred from highway transports to nurse tanks prior to land application.

TRANSPORT METHOD

Liquid Transport: <18% solids

- sealed tanks used only for transport
- tankers should be equipped with baffles to reduce internal movement of liquids
- dedicated pumps and hoses are used to load and unload materials
- nurse tanks may be used at the application site as interim holding tanks between hauling equipment and the land application operation

Bladders are used for temporary storage at the staging area for application operations.

Specialized application equipment is used to handle dewatered biosolids.

Solid Transport: >18% solids

- usually transported by truck and covered trailer
- loaded and handled by front-end loaders, conveyors and other industrial equipment

BIOSOLIDS HANDLING

Biosolids handling includes the transfer of liquid biosolids from tanker to the application system at the field site. Nurse tanks and storage bladders are temporary containment devices used in the field to store liquid materials in the interim between hauling and land application. Material cannot be left in these devices overnight.

With all biosolids handling systems, human safety and environmental protection are priority concerns during these activities.

BMPs for Nurse Tanks and Storage Bladders

If you're using a nurse tank, it should be:

- leak-proof
- equipped with emergency shut-off valves, and
- equipped with safety grills to prevent human entry.

Location-wise, there are minimum regulated separation distances that must be adhered to. As a BMP, a nurse tank or bladder should be located on level ground as far away from sensitive features such as wells and surface water as is practical, while still accessible to delivery equipment. The objective is to ensure minimal environmental damage in case of a spill, and minimal impact on neighbours from odours and activities associated with a land application operation.

Vacuum-loading arms work well for unloading tankers. Where appropriate, farmers should include them in contingency plans, as they're also useful in case of a spill.

CONTINGENCY PLANNING

The best way to prevent emergencies is to set out and follow the BMPs and guidelines for application.

Generators and haulers/land applicators are required to draw up a contingency plan and take the necessary precautions, in case an emergency arises. Being prepared is the best defence.

SPILL PREVENTION

✔ Train staff. Instruct staff about road and load safety, suitable routes, and driving practices.

✔ Develop and review a spill protocol that includes instructions on containment, contacts, and reporting procedures.

✔ Inspect all safety features prior to haulage: hatches, seals, tires and running gear.

Contingency plans are not worth the paper they're written on *unless* they're followed up by adequate staff training and spill cleanup materials.

IN CASE OF A SPILL

✔ Stop the source: stop the leak at the source.

✔ Contain the spill: use bales or other absorbent materials to contain spill.

✔ Clean up: use loaders or vacuum equipment as appropriate to clean up the mess.

✔ Report the spill: have contact numbers prominently placed on hauling equipment

► call MOE Spills Action Centre, 1-800-268-6060.

APPLICATION SITE CRITERIA

Sewage biosolids can only be applied to agricultural land that's suitable to receive them and where location and site conditions don't restrict or prohibit application.

SURFACE SLOPE

The steepness, length and shape of the surface slope can influence the potential movement of liquid or solid sewage biosolids through runoff or soil erosion.

SURFACE SLOPE AND POTENTIAL MOVEMENT OF BIOSOLIDS

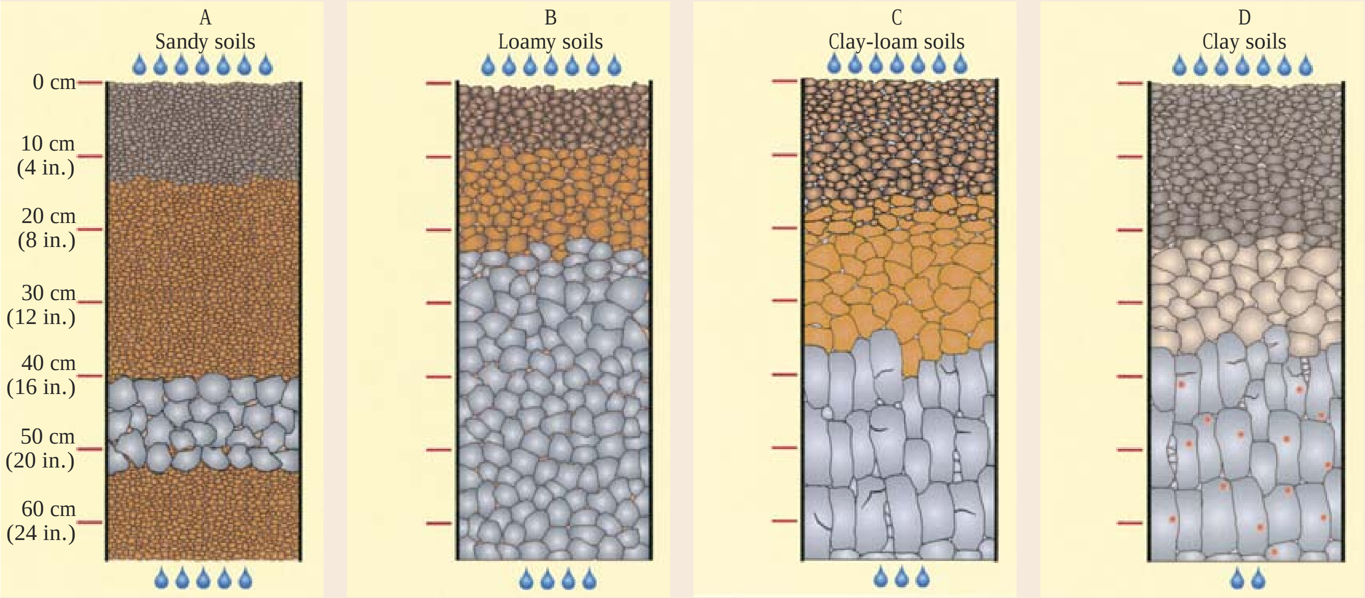
SURFACE SLOPE	IMPLICATIONS
0–<3%	• considered best for maximizing soil infiltration and absorption, while minimizing potential for lateral surface flow in the form of runoff or erosion
3–<6%	• is highly suitable with careful management (e.g., conservative application rates)
6–<12%	• poses an increased risk of runoff if liquid sewage biosolids are to be applied • usually requires incorporation or reduced application rates
≥12	• cannot be applied if the slope is within 150 metres (492 ft) of the top of bank of surface water • if distance is greater than 150 metres (492 ft) from the top of bank of surface water, as a BMP, applications are not recommended on slopes of 12% and greater, due to risks of liquid biosolids movement downslope and pooling in low areas

Slope is measured as a percentage of elevation difference over a specified length. For example, a 6-metre (20 ft) incline over a 100-metre (328 ft) distance is a 6% slope.

SOIL PERMEABILITY

The rate at which a liquid will infiltrate and move down through a soil depends on the permeability of the soil.

HYDROLOGIC SOIL GROUP	IMPLICATIONS
A, B SANDY SOILS, LOAMY SOILS	• A and B soils have a high infiltration and conductivity rate • liquid sewage biosolids may move quickly into and downward through these soils • applying too much liquid sewage biosolids to these soils may result in the leaching (seepage) of nutrients below the rooting zone and down into groundwater before they can be taken up by the plant roots
C, D CLAY LOAMS, CLAYS	• C and D soils are less permeable and have a lower infiltration and conductivity rate • sewage biosolids applied to these soils are more likely to be retained within the rooting zone and taken up by crops – this reduces the risk of nutrients leaching to groundwater, but care must be taken to avoid pooling

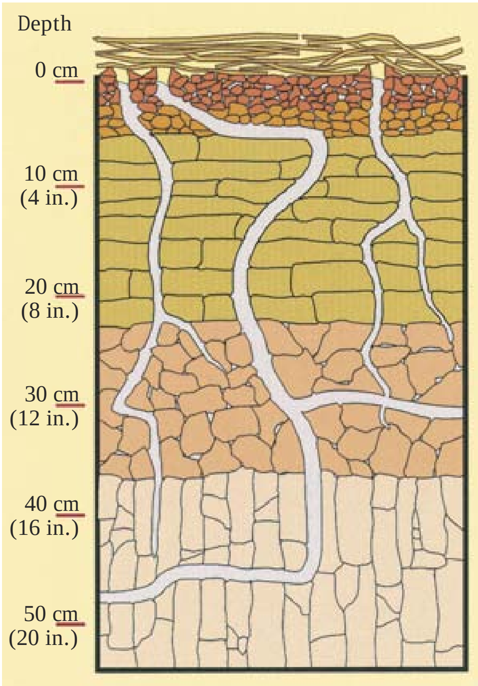


Group A is sand, loamy sand or sandy loam types of soils. They have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels, and have a high rate of water infiltration.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well-drained soils.

Group C soils are sandy clay loam, clay loams, and silty clay loams. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, and soils with moderately fine to fine structure.

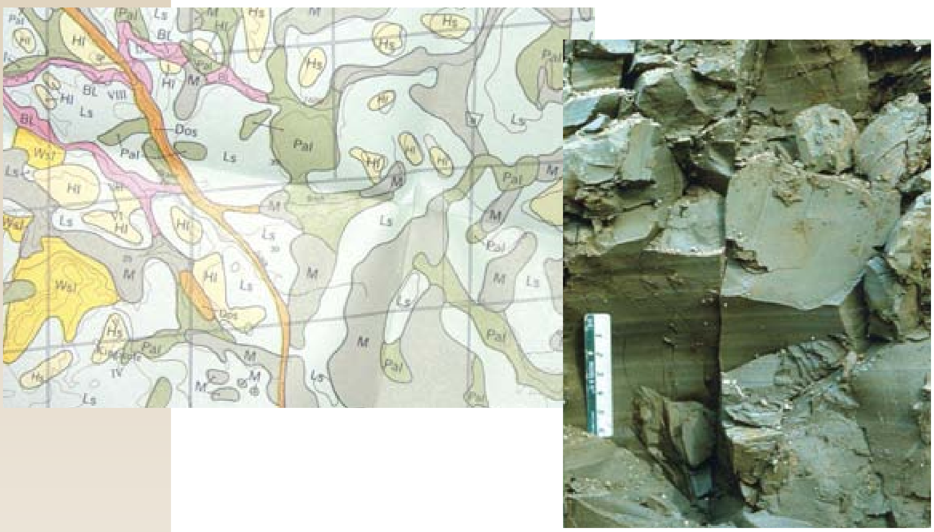
Group D soils are sandy clay, silty clay or clay. This HSG has the highest runoff potential. These soils have very low infiltration rates when thoroughly wetted and consist of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.



Following application, liquid sewage biosolids can travel in soils through cracks, worm channels, and large continuous pores. In advance of applying liquid sewage biosolids, pre-tilling soils that are prone to cracking can reduce risk.

SOIL DRAINAGE

The rate at which excess water will naturally be discharged or will move through and out of a soil can influence the rate and timing of sewage biosolids application.



Poorly drained soils, shown in this profile and scanned soil map (map unit symbol Pal for Parkhill loam), may be unsuitable for biosolids applications.

SOIL/SITE FACTOR	CONSIDERATIONS
POORLY DRAINED SOILS	• these soils discharge water slowly and tend to stay wet for longer periods in early spring and late fall as compared to well or imperfectly drained soils • they may wet up quickly after substantial rainfalls – when soils stay wet longer, there can be a risk of compaction, runoff and/or erosion • poorly drained soil series (or types) are identified on soil maps
IMPERFECTLY OR WELL-DRAINED SOILS	• these offer greater flexibility than poorly drained soils in terms of biosolids application
WELL-STRUCTURED SOILS WITH MACROPORES	• macropores may act as direct conduits to tiles or groundwater • minimize risk with lower application rates and/or tillage prior to application
PRESENCE OF SUBSURFACE TILE DRAINAGE	• used to improve imperfect and poorly drained soils ○ improved in-field drainage allows field operations earlier in the spring and later in the fall, and sooner after rain events as compared to a non-tiled field • take care during application to avoid movement down through the soil to the drainage pipe (tile) and subsequent discharge to a watercourse or drainage ditch • delay application or take extra caution when applying liquid sewage biosolids to a field with subsurface drainage if water is flowing from the outlets • monitor outlet water (outfall) frequently • pre-till prior to application to disrupt potential pathways (e.g., cracks or macropores) down to the drainpipes (tiles) to further reduce the risk of biosolids reaching the outlets (outfall) • don't apply sewage biosolids within 20 m (65 ft) of a surface inlet (e.g., Hickenbottom drain) that outlets to surface water
DEPTH TO WATER TABLE	• need to ensure regulatory compliance • ensure adequate depth to groundwater to minimize the risk of leaching of nutrients out of the root zone and down into groundwater • use management practices such as pre tillage or lower application rates of liquid biosolids to minimize risk
SOIL TYPE	• sandy (coarse) soils ○ have large pores, drain quickly, with minimal retention of applied liquids ○ higher rates could pass through rooting zone • loamy (medium) soils ○ diverse pore size, drain at a moderate rate, and retain a moderate amount of liquid materials ○ loamy soils in good condition have higher loading capacity • clay (fine) soils ○ have small pores, drain slowly, and retain applied liquids in small pores ○ higher rates could lead to runoff

SOIL/SITE FACTOR	CONSIDERATIONS
SLOPE	• with higher application rates, the risk of runoff increases with steepness of slope • slopes steeper than 12% significantly increase the risk of runoff and application is not recommended
DEPTH TO WATER TABLE	• soils with high water tables have less storage capacity for applied liquid materials, thus posing a higher risk for groundwater contamination
DEPTH TO BEDROCK	• soils shallow to bedrock are closer to the point of application or injection – posing a higher risk for groundwater contamination
SETBACK DISTANCE TO SURFACE WATER	• a regulatory requirement • reduce the risk of surface water contamination
SETBACK DISTANCE TO WELLS	• necessary for fields and sites adjacent to wells to reduce the potential risk of well contamination from surface runoff, or the remote risk of subsurface movement of contaminated groundwater

APPLICATION METHODS AND EQUIPMENT

Sewage biosolids can be applied as a liquid or a solid. The most appropriate application method for agricultural land depends on the physical characteristics of the biosolids and the soil, as well as the types of crops grown.

Biosolids are commonly injected or incorporated into the soil by ploughing or disking after the biosolids have been applied unless minimum or no-till systems are being used. Biosolids application methods such as incorporation and injection are implemented to retain nutrients and reduce runoff, odours, and vector attraction.

LIQUID BIOSOLIDS

Liquid application is attractive because of its simplicity and flexibility in application options. Liquid sewage biosolids can be pumped from the storage facility to transportation vehicles, and then transported to field sites to be pumped directly from the vehicle to the field application equipment.

Liquids can be surface-applied to pastures – provided the proper waiting times (at least two months) are followed.

Liquids can be surface-applied and incorporated, or injected directly into the soil.

SURFACE APPLICATION

Equipment used for surface application includes tractor-drawn tank wagons, special applicator vehicles, and tank trucks with flotation tires to minimize compaction on moist soils. Historically, high-trajectory guns were sometimes used for surface application of biosolids. Due to a number of issues such as inaccurate application, this practice is no longer allowed in Ontario.

INJECTION

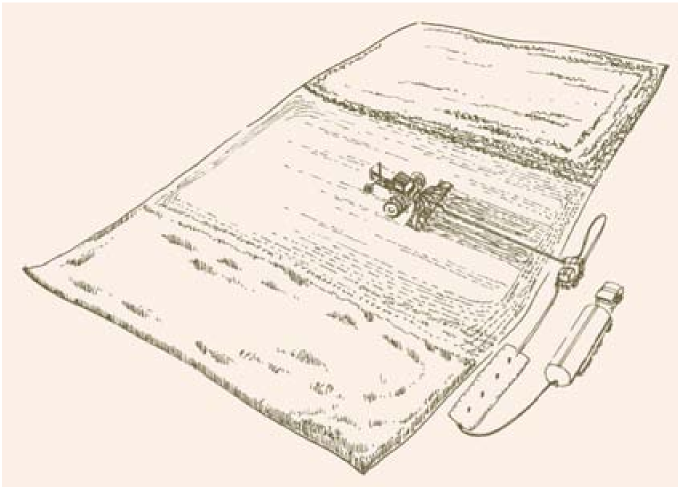
Liquid biosolids can also be injected below the soil surface using:

- tractor-drawn tank wagons with injection shanks
- tank trucks fitted with flotation tires and injection shanks
- tractor-mounted injection and drag hose systems.

This equipment minimizes odour problems and reduces ammonia volatilization by the immediate mixing of soil and biosolids. Injection can be used before planting, between the rows of crops like corn while the crop is growing, or after harvesting.

Subsurface injection can also help minimize runoff. Injection should be made perpendicular to slopes to avoid having liquid biosolids run downhill along injection slits and pond at the bottom of the slopes.

Injection isn't recommended for forages and sod production. Injection shanks can damage the sod or forage stand and leave deep injection furrows in the field.



Injection across slope – or in concert with cross-slope contour cropping designs – will drastically limit the risk of runoff.

DEWATERED BIOSOLIDS

Dewatered sewage biosolids may be less costly to transport, but usually require post-application incorporation. Typically, solid or dewatered sewage biosolids are applied to cropland using equipment similar to that used for applying lime, animal manures, or commercial fertilizer. Because of the low water content, these sewage biosolids can be ploughed or disked into the soil immediately after application. New technology has been developed to inject some types of dewatered sewage biosolids.

Dewatered biosolids are applied using specialized injection equipment or modified livestock manure application equipment.

NUTRIENT MANAGEMENT PLANNING FOR SEWAGE BIOSOLIDS

This chapter directly addresses Ontario farmers considering having sewage biosolids applied to their fields. We'll walk through the details of developing and implementing a nutrient management plan for a farming operation where biosolids are used. Checklists for haulers and applicators are included. (A case study of such an operation appears later on page 102 to help illustrate the steps and the real-life management implications.)

On September 18, 2009, Ontario Regulation 267/03 (the nutrient management regulation) was amended. The majority of the amendments were related to the management of the application of non-agricultural source materials (NASM), including sewage biosolids, on agricultural land.

Most of the regulatory changes related to the land application of NASM will take effect January 1, 2011. These changes include the requirement of a NASM plan for all NASM application areas unless a valid Organic Soil Conditioning Site Certificate of Approval issued by Ontario Ministry of Environment is in place.

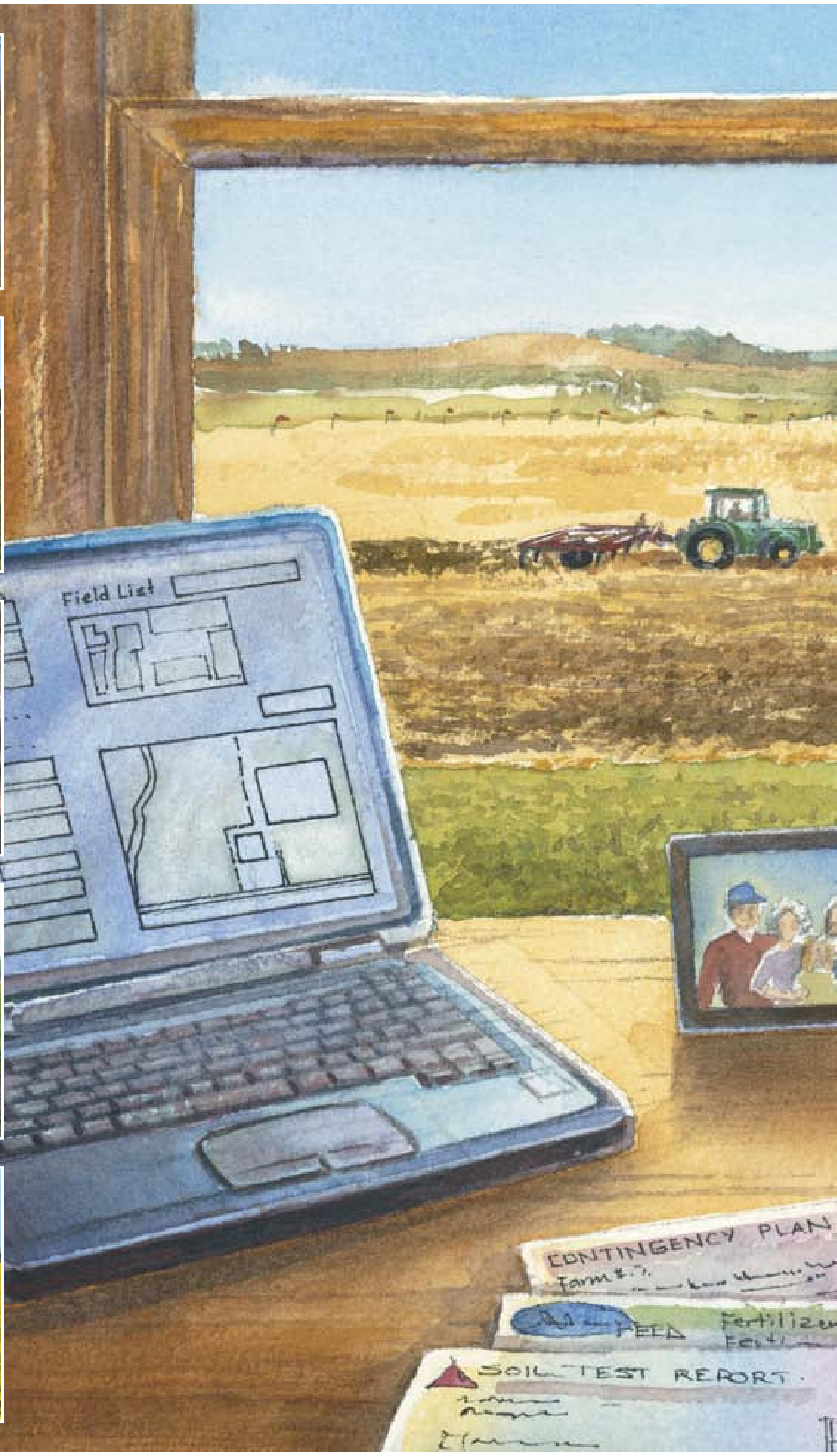
This chapter reflects the regulations related to the application of NASM on agricultural land under O.Reg. 267/03 as of January 1, 2011.

10 STEPS TO MAKING IT WORK

Nutrient management planning for sewage biosolids is an in-depth process. But it doesn't have to be overwhelming – especially when you take it step-by-step.

1. Set goals
2. Take inventory
3. Input and analyze data
4. Develop options
5. Make decisions
6. Take actions
7. Keep records
8. Monitor
9. Make adjustments to your plan
10. Plan for the unexpected

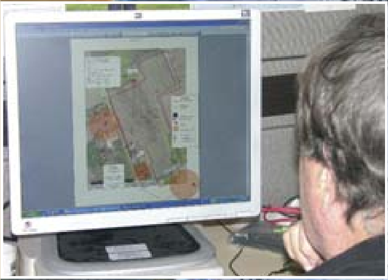
Sometimes the best spokesperson for the use of municipal biosolids in a crop fertility program is the farmer who is using the material. Here, Harry Buurma presents his thoughts on the subject.



Step 1 – Set goals
Goal-setting states your direction for nutrient management planning and helps with decision-making. Seek advice from trusted sources to help form goals.

Step 2 – Take inventory
This step includes resource description, taking soil samples for analysis, and an accounting of current management practices.

Step 3 – Input and analyze data
Use the information collected in Step 2. OMAFRA software (pg. 70) will help evaluate application practices and help develop suitable application rates.



Step 4 – Develop options
Based on the results of your data analysis, develop options to manage risk, decrease input costs, and handle all nutrients generated.

Step 5 – Make decisions
Select management options to meet your goals. Choose and plan proper application rates and maintain separation distances.

Step 6 – Take action
"Walk the talk" to meet your goals. Make an operational plan and adjust for weather conditions.

Step 7 – Keep records
Show due diligence while keeping records for future planning. Maintain records for application rates, biosolids analyses, cropping, and monitoring results.

Step 8 – Monitor
Monitor the operation and resources to verify crop quality yield expectations and resource protection, and ensure the operation is not a nuisance for neighbours.

Step 9 – Make adjustments to your NASM plan
Fine-tune your plan, and upgrade technology where appropriate. Use information from record-keeping and monitoring to modify plan. Repeat Steps 3–6 if necessary.

Step 10 – Plan for the unexpected
Develop a contingency plan, document actions, and communicate to others involved.

STEP 1 – SET GOALS

Nutrient management plans for the land application of sewage biosolids are normally developed to do one or more of the following:

- determine where biosolids are best used in your operation
- optimize economic yields
- manage input costs
- protect soil and water resources
- ensure compliance with nutrient management regulations.

Identify which of these considerations relates to your farming operation now so that you can continue to focus on these throughout the planning process.

If you're less than comfortable with compiling the data required for your plan, or have a complex farm operation, you might consider creating a team of advisers (e.g., land application representative, crop consultant, a certified NASM plan developer, or hired help) to assist you.

In many cases, generators and licensed biosolids application companies work with, or have on staff, certified NASM plan developers who will develop a NASM plan for a biosolids-receiving operation. A NASM plan approved by the Ontario Ministry of Agriculture, Food and Rural Affairs is required for every sewage biosolids land application site.

Seek advice when setting goals for your NASM plan and biosolids application operation.

CITIZEN/LANDOWNER INVOLVEMENT

Generally a certain level of public involvement is encouraged when planning land application of biosolids. Neighbours who have been engaged and informed well in advance of biosolids use may be more tolerant than those left out of the loop. Ensure that neighbours are advised of your intentions to use sewage biosolids in your cropping program.

Biosolids haulers and professional agronomists work hand-in-hand with regulatory agency staff and other agencies to establish public education and outreach, oversee land application activities, and assist with citizen issues.

STEP 1 Set goals
STEP 2 Take inventory
STEP 3 Input and analyze data
STEP 4 Develop options
STEP 5 Make decisions
STEP 6 Take action
STEP 7 Keep records
STEP 8 Monitor
STEP 9 Make adjustments to your NASM plan
STEP 10 Plan for the unexpected

STEP 2 – TAKE INVENTORY

An inventory of your field resources is required to determine site suitability for land application of biosolids.

It's also an essential step in developing a useful NASM plan and choosing the most suitable BMPs for effective application.

Read on to learn what information you need to collect, and what resources can assist you in the process.

Site information is required to determine if specific fields are suitable (i.e., a manageable risk) for biosolids application. This information also helps the development of a comprehensive nutrient management program.

INVENTORY INFORMATION NEEDED TO DEVELOP A NASM PLAN

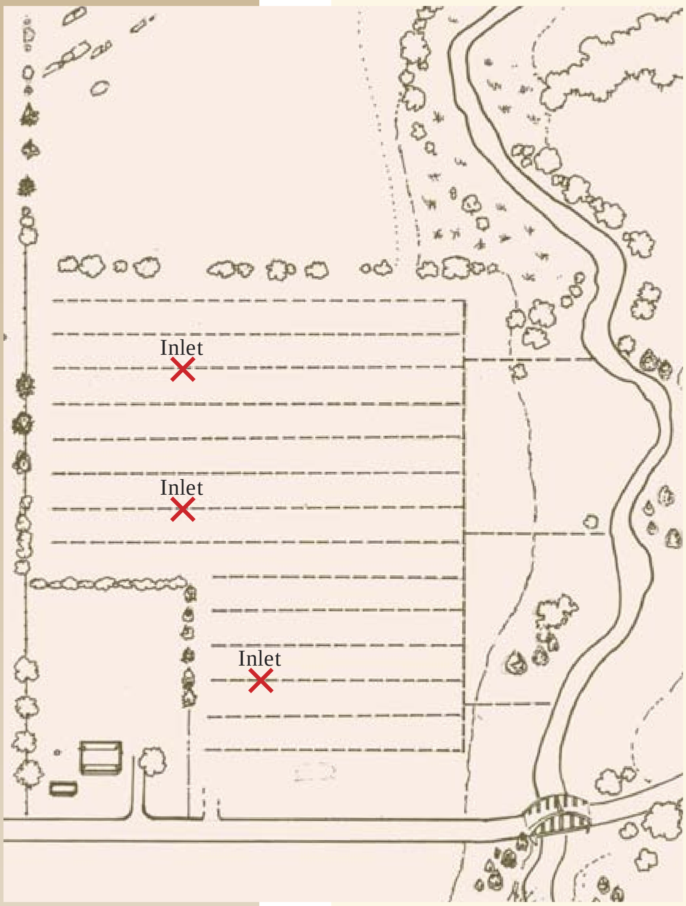
There are clear linkages between the information required for site approval and the site information that helps form the basis of a comprehensive and meaningful NASM plan.

Your nutrient management inventory will only be as good as the information you put into it. In this section you'll learn about:

- soils information
- field sketch
- crop inventory and yield information
- soil test
- biosolids analysis.

Check your local soil map to determine soil type, texture, and slope on your candidate fields. Take soil samples to test for nutrient levels (fertility).

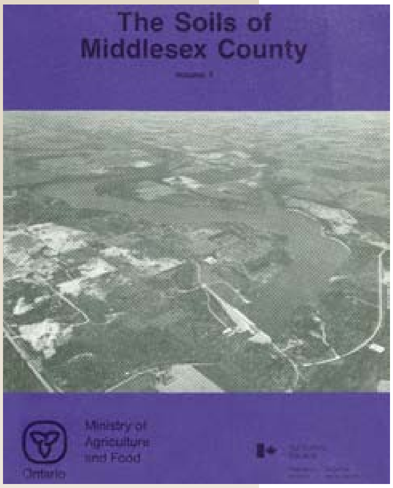
GETTING READY FOR INVENTORY



Having the following items on hand before getting started will speed up the process:

- ► contact names for laboratory services, sources for maps or aerial photos, and contact info for consulting services (if desired)
- ► county soil map and report
- ► topographic maps or aerial photographs for your property
- ► field measuring wheel or global positioning system (GPS)
- ► distance measurements – between facilities and lot lines, wells (all types), surface inlets and surface water bodies (e.g., creeks, streams, ponds)
- ► field slope measurements or tools for measuring slope in the field – clinometer, stake and string
- ► locations of tile outlets, buffer strips, surface inlets, wells
- ► crop records – crops grown, yield, recent nutrient application, soil test results
- ► soil sampling equipment – shovel or soil sample probe, bucket, soil test bags/boxes.

Knowing where subsurface drainage features are located is important to help applicators follow the application plan and maintain separation distances from inlets.



SOIL INFORMATION

Soil maps show your soil types, their properties (materials, slopes, natural drainage class, stoniness), and extent of these soils on your farm or application site.

Soil reports can provide important information on:

- ► slope and erosion risk
- ► hydrological groups for use in a NASM plan, and in some cases,
- ► liquid loading limits for application rates.

NITROGEN INDEX (N INDEX)

The N Index is a tool for reducing the risk of nitrate contamination of groundwater. It evaluates the vulnerability of nutrient management practices with respect to the movement of nitrates. The N Index combines source and transport factors to assess the risk of nitrate movement to groundwater on a field-by-field basis.

PHOSPHORUS INDEX (P INDEX)

The P Index is a tool for reducing the risk of phosphorus contamination of surface water. It assigns a value to the risk of surface water contamination from nutrient application to cropland. The value is based on soil phosphorus levels, amount and method of phosphorus application, soil type and site characteristics, and tillage management in the vicinity of the surface water body.

Both maps and reports can also help you recognize potential environmental risks and unseen areas of your soil (subsoil and geology) that may impact application management.

SOIL MAP SYMBOLS

Numerator	single soil →	Busl	multiple soils →	Hosil-G
---------------		---------------		---------------
Denominator	single slope →	B	multiple slopes →	B>C=D

SOIL TEXTURE ABBREVIATIONS

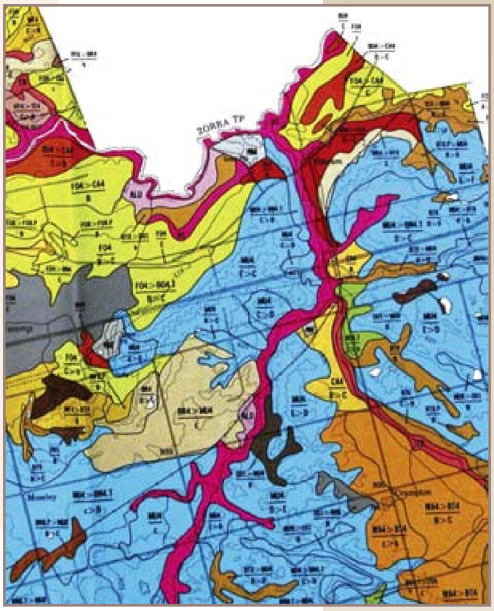
l	=	loam
sl	=	sandy loam
ls	=	loamy sand
cl	=	clay loam
sil	=	silt loam
s	=	sand
c	=	clay
si	=	silt

SLOPE CLASSES

A, a……0–0.5% slope	Level
B, b……0.5–2% slope	Level to nearly level
C, c ……2–5% slope	Very gently sloping
D, d……5–9% slope	Gently sloping
E, e ……9–15% slope	Moderately sloping

Upper case = Long (>50 m or 164 ft) simple slopes

Lower case = Short (<50 m or 164 ft) complex slopes that intersect each other

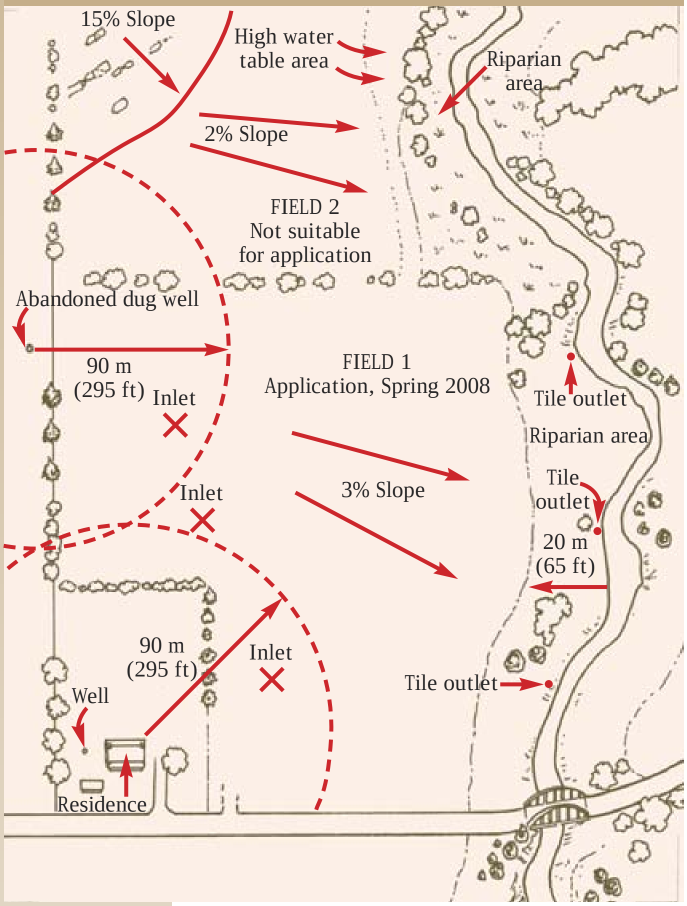


How to use soil survey information:

- **locate map units for area**
- **determine soil series and slope information from legend found on soil map**
- **use soils report and *Drainage Guide* for descriptions and interpretations.**

FIELD SKETCH

E 1/2 L19 C12 EUPHRASIA



A field sketch should identify location(s) of the following:

- lot and concession
- field sections
- presence of tile drains within a field
- tile inlets and outlets
- surface water within 150 metres (492 ft) of the field
- non-agricultural land uses
- all wells within the field and within 100 metres (328 ft) of a field boundary
- slopes
- other physical features such as rock outcrops.

SETBACKS FROM HICKENBOTTOMS, CATCHBASINS AND OTHER TILE INLETS

A 20-metre (65 ft) setback from surface inlets must be maintained.

Surface tile inlets such as Hickenbottoms are not defined as surface water, but they are direct conduits to surface water, and therefore should be protected when spreading sewage biosolids.

They should be treated as surface water (given a setback and maybe even a vegetated buffer). Doing nothing isn't an option.

CROP INVENTORY AND YIELD INFORMATION

You should have accurate crop and yield information to develop an effective nutrient management plan. You'll need to know:

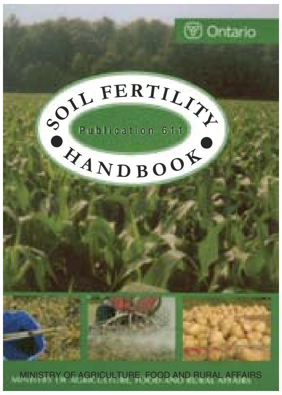
- crop rotation
- average yield (five-year average to cover weather impact) – to determine nutrient needs and to estimate nutrient removal
- previous crop (e.g., are there any nitrogen credits?)
- field soil test results
- previous NASM applications within the past four years
- commercial fertilizer and other nutrients (livestock manure) applied or planned.

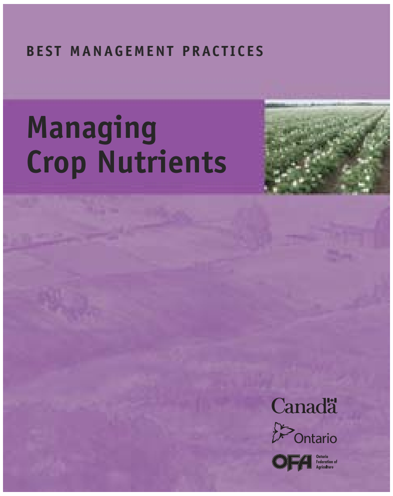
SOIL TEST

The soil test is a measure of the major nutrients and micronutrients and will indicate the likelihood of crop response to applied nutrients. Soil test results are the starting point for future determination of crop needs and potential environmental areas of concern.

Soil from fields being considered for sewage biosolids application must be analyzed for phosphorus, pH, and the 11 regulated metals.

For more information regarding soil tests and fertility, refer to the *Soil Fertility Handbook,* OMAFRA Publication 611.





The BMP book *Managing Crop Nutrients* is also an excellent resource for information on soil testing.

Ontario Accredited Soil Test Laboratories Ltd.
FARM SOIL REPORT

Report 62269 for G Smith
Received 10/09/08
Printed 15/09/08

	Analytical Values					mg/kg	milligrams per		litre of soil (ppm)										
#	Field I.D.	Lab #	pH	BpH	O.M. %	NO_3-N	Phosphorus		K	Mg	Ca	Texture	Mn		Zn		% Base Saturation		
							$NaHCO_3$	Bray P					ppm	Index	ppm	Index	K	Ca	Mg
1	field 1 North half	998701	7.1		3.5		28 H		187 VH	112	2049	M					4.1	8.0	87.9
2	field 1 South half	998702	7.2		3.2		33 VH		220 VH	167	2236	M					4.3	10.6	85.1
3	field 2 North half	998703	6.9		4.0		35 VH		210 VH	127	1242	M					6.0	11.8	68.9
4	field 2 South half	998704	5.7	6.8	2.8		25 H		175 VH	158	897	C					5.2	15.2	51.8
5	field 3 North half	998705	7.0		3.8		14 M		108 VH	118	2710	F					1.9	6.6	91.5
6	field 3 South half	998706	7.1		3.3		26 H		160 VH	120	2814	F					2.7	6.5	90.9
7	field 1 eroded knoll	998707	7.6		1.8		50 VH		235 VH	150	3257	M	2.5	14	1	14	3.3	6.9	89.8

Soils with a test result of >60 mg/l (ppm) based on Olsen sodium bicarbonate P test are not eligible for sewage biosolids application.

BIOSOLIDS ANALYSIS

Municipal wastewater treatment plants are required to test their sewage biosolids on a regular basis. The biosolids must be analyzed at a lab, using accredited methodologies. The analysis includes:

- total Kjeldahl nitrogen
- ammonium–nitrogen
- ammonia–nitrogen
- nitrate–nitrogen
- nitrite–nitrogen
- pH
- total phosphorus
- the 11 regulated metals.

The results of the analysis are averaged over time and the average concentration of each of the 11 regulated metals cannot exceed strict regulatory limits. If they do, the biosolids cannot be applied to agricultural land.

The analysis must include E. coli., an indicator organism used to monitor the effectiveness of the treatment process in the reduction of potentially pathogenic organisms that may be in the sewage biosolids. Sewage biosolids intended to be land-applied must have a geometric mean concentration of E. coli of less than 2×10^6 colony-forming units per gram total solids.

STEP 3 – INPUT AND ANALYZE DATA

Step 3 aims to:

- determine usable land base and, for biosolids application, interpret the inventory information for site suitability
  - inventory information is interpreted to determine if there are sufficiently few restrictions to make candidate fields suitable for application
- establish the nutrients required for the planned crop on a field-by-field basis.

SITE SUITABILITY FOR APPLICATION

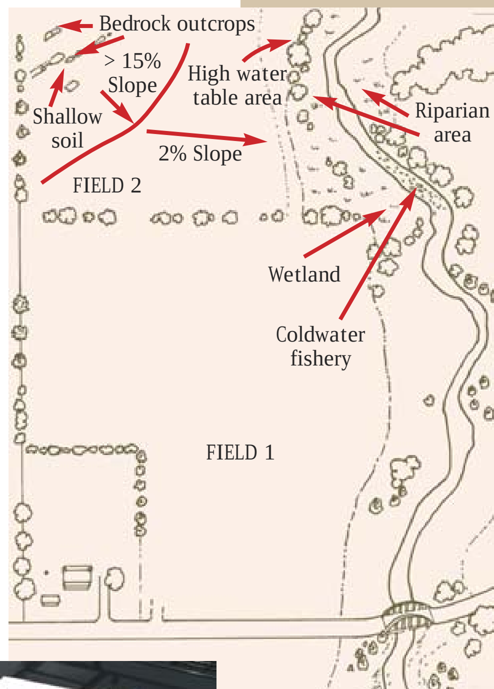
Site physical characteristics that influence the land application management practices include those physical properties that affect risk to groundwater or surface water contamination such as:

- topography
- soil permeability
- infiltration
- drainage patterns
- depth to groundwater and bedrock
- proximity to surface water and wells.

Regulations may place limits on land application based on these physical characteristics (see table on next page).

Areas where biosolids application is not permitted include:

- immediately adjacent to lakes, rivers, and streams without appropriate buffer areas (floodplains)
- wetlands
- steep slopes
- undesirable geology (karst, fractured bedrock) if not covered by a sufficiently thick layer of soil
- undesirable soil conditions (rocky, shallow, organic soils).



These areas need to be identified and indicated on maps or sketches for site approval.

CONSIDERATIONS FOR SITE SELECTION	
ITEM	**DETAILS**
SITE SELECTION PRE-SCREENING **All of the site characteristics below have associated regulatory requirements involving setbacks or application rate restrictions depending on the specific characteristic. The requirements are set out in Ontario Regulation 267/03.**	
SEPARATION DISTANCES TO RESIDENCES AND RESIDENTIAL AREAS	• Maintaining adequate separation distances from residences, residential areas, and other areas of commercial or community use reduces the impacts of odours and dust on neighbouring properties. • There are required regulated minimum separation distances that must be followed in O.Reg. 267/03.
LAND USE RESTRICTIONS	• Farmer is willing to agree to crop restrictions following biosolids application as follows: ○ hay and haylage ➧ 3 weeks before harvest ○ commercial sod ➧ 12 months before harvest ○ tree fruits and grape ➧ 3 months before harvest ○ small fruits ➧ 15 months before harvest ○ vegetables and tobacco ➧ 12 months before harvest ○ horses, beef and dairy cattle ➧ 2 months before grazing ○ swine, sheep and goats ➧ 6 months before grazing.
SOIL DEPTH/TYPE	• Soil maps are reviewed to determine whether there is likely to be adequate and suitable (i.e., mineral) soil. • Application to organic soils (>17% organic matter) is not permitted. • Visual inspection of the soil type may be used instead of soil maps. • Hydrologic soil group must be determined if the application site is within 150 m (492 ft) of the top of bank of surface water. • Shallow soil depth may restrict application rates.
SOIL P LEVELS	• Sites with soil test P >60 mg/L (ppm) based on Olsen sodium bicarbonate P test are not eligible to receive sewage biosolids.
SOIL METAL LEVELS	• Sewage biosolids cannot be applied to a site if any of the regulated metal concentrations in the soil exceeds the maximum permissible concentration (see table on pg 38).
SITE ASSESSMENT	
SOIL DEPTH TO BEDROCK	• Soil depth should be measured by at least one test hole per 10 hectares (25 ac) evenly distributed over the property (minimum one location per site). • Locations of test holes are indicated on the site plan. • The optimum depth to bedrock should be at least 1.5 m (5 ft). Shallower depths may be considered if application rates are lowered and/or the soil is tilled prior to application of the sewage biosolids. • Where rock outcrops are visible, appropriate setbacks should be indicated on the site plan.
FIELD MEASUREMENT	• The field and buffer areas should be measured to within **5%** of actual using differential GPS or air photos and software capable of calculating the area. • Once buffer areas have been identified, their area is accurately measured and deducted from the total field area.

CONSIDERATIONS FOR SITE SELECTION	
ITEM	**DETAILS**
SITE ASSESSMENT (continued)	
LANDOWNER CONSENT	• Signed consent is obtained from the landowner indicating an understanding of: ○ waiting periods ○ crop restrictions ○ specific area where biosolids will be spread (shown on site plan) ○ amount of nutrients being provided by biosolids. • Where the landowner is different from the farm operator, the farm operator will also sign to indicate understanding of the above items. The signatures of both parties are required on a NASM plan.
FLOODPLAIN LOCATION	• Areas will not be selected that are subject to frequent flooding (annual or biannual) based on visual observations or floodplain mapping. • Where a portion of the site is subject to flooding as defined above, it will be delineated on the site plan and excluded from the spreadable area.
FIELD SKETCH	• An accurate field sketch should clearly delineate: ○ site boundaries, buffer areas around wells, and surface water ○ topographical features (slopes and rock outcrops) ○ location of residences, residential areas, and setbacks ○ wells – in field and within 100 m (328 ft) – by type (drilled, dug, municipal) ○ surface water and tile drain inlets and outlets ○ setbacks from sensitive features ○ test hole locations ○ staging area ○ field entrance ○ proposed stockpile location if applicable.

REQUIRED NUTRIENTS

Once the site is considered suitable, the next step is determining which nutrients are required for the planned crop. This requires an accounting of the amount of nutrients left from previous crops (soil test results and credits), and nutrients available from biosolids based on specific management practices.

Inventory information must also be considered to establish potential restrictions and/or setbacks from surface water sources and other sensitive features (wells and residences).

The analysis process involves calculating nutrient balances and ensuring they are within regulatory limits. OMAFRA has developed a software package to assist certified NASM plan developers in the development of NASM plans. The software uses a comprehensive, field-by-field approach that includes site characteristics, with information about crop rotation, tillage, and timing of operations.

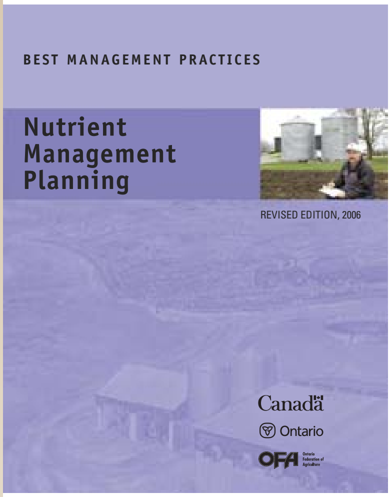
The OMAFRA software is the recommended program to be used to determine required nutrients, application rates, and usable areas (i.e., areas without restrictions or setbacks) in a field for nutrient application.

The software is available by calling OMAFRA, 1-877-424-1300.

The completion of Step 3 generates the information from which to determine the risks as well as the opportunities within the plan. The analysis step should highlight potential areas of concern that should be addressed in the plan.

The result will be only as good as the information entered. Analysis depends on a thorough understanding of the cropping management on your farm. It requires a commonsense approach to timing of nutrient application in light of the soil and cropping characteristics.

For more information on related topics, see the BMP book, *Nutrient Management Planning*.



When nitrogen (N) left over at crop harvest is combined with N from biosolids applied in late summer or early fall, the potential loss of N from the soil through leaching or denitrification could be significant.

Some of the information will be based on long-term knowledge of the land base and site conditions, and on personal observations.

Some key outcomes from the calculations that are of concern in biosolids application include the following four factors.

P and N Indexes are tools to help limit the amount of nutrient lost from the field to the environment. Both are calculated as part of the software.

Application Rate

The biosolids application rate matches the P or N (whichever is lower) removed by the crop with allowance for soil buildup of crop nutrient removal for P. In order to build up phosphorus levels in the soil, a P application rate of up to 78 kg/ha (69 lb/ac) above what the crop removes per year is allowed.

P Index

If the P soil test is 30 ppm (mg/L) or higher, completing the P Index is a recommended BMP. The environmental impacts of P transport to surface water will be greater if the P Index is 30 or higher and significant erosion occurs. The P Index considers erosion potential and level of P in the soil to calculate a phosphorus separation distance.

If the P soil test is >60 ppm (mg/L), then biosolids application is not permitted.

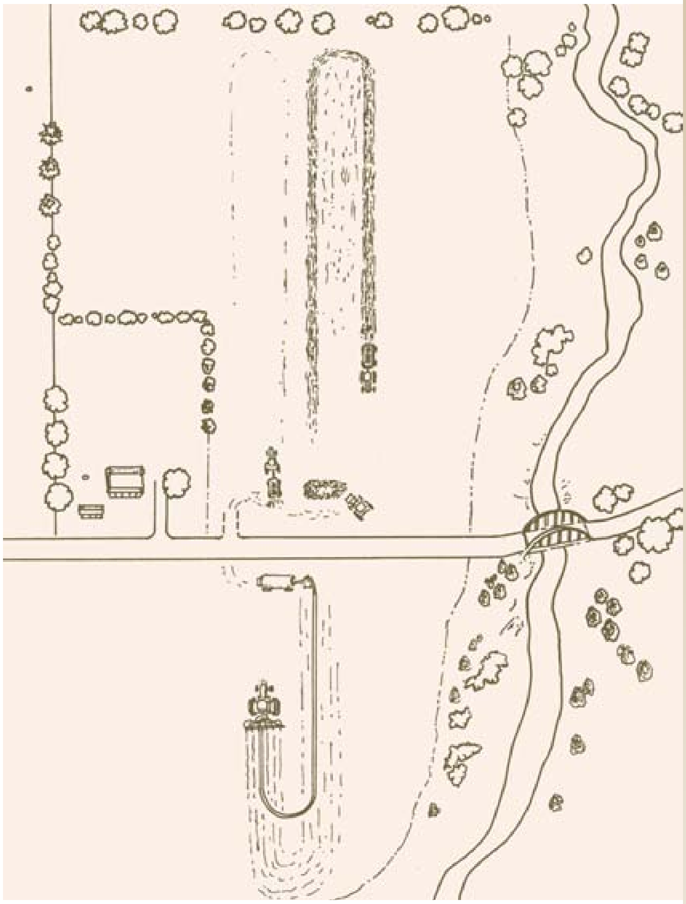
N Index

When N rates exceed crop removal, calculating the N Index is a recommended BMP to limit potential N loss by leaching during the non-growing season.

Separation Distances

Separation distances are specified in provincial regulations and were established to protect surface water and groundwater resources.

Surface-applied liquid biosolids may require a larger separation distance than dewatered solid biosolids or liquid biosolids pre-tilled, injected or immediately incorporated. See O.Reg. 267/03 for more details.



Surface-applied liquid biosolids separation may require a larger separation distance from surface waters than surface-applied dewatered (solid) biosolids.

"Liquid loading limit" is the maximum application rate at which liquid biosolids can be applied to minimize the risk of material moving over the surface. It's determined from the runoff potential (slope and soil texture), and limits the application rate to one that can be absorbed by the soil. This loading limit can result in a requirement for reduced or split applications (e.g., several days apart).

Cropland buffers can help in reducing red flag triggers.

GREEN, YELLOW AND RED FLAGS: WHAT ARE THEY?

The software program uses different-coloured flags to indicate risk level. Green means data are acceptable. Yellow means that information is missing or there are conditions that approach environmental risk or poor economic resource use.

Red BMP flags (identified by a lighter red colour or by a stop sign containing an "!") represents an area of environmental concern. Changes may be needed in the nutrient planning system to eliminate these flags.

STOP ARRÊT **Red legislative flags** (identified by a deep red colour and a stop sign) indicate a legislative infraction according to Ontario Regulation 267/03. A regulated NASM plan submitted for approval with these warning flags may not be acceptable.

Here's a sampling of red flag triggers:

- STOP ARRÊT Biosolids application rate in one application exceeds the maximum liquid loading rate.
- The nitrogen available for loss from fall-applied materials exceeds the lower of 120 lbs/ac or the maximum N Index value based on the field's hydrologic soil group.
- STOP ARRÊT Biosolids application rate results in a regulated metal application in excess of permitted limits.
- STOP ARRÊT The soil pH of the receiving field is <6.0 or the P soil test is >60 ppm or any of the regulated metal concentrations in the soil exceed the permitted concentration.

INTERPRETING SOIL TEST RESULTS

The recommended approach to nutrient application is applying nutrients at rates that optimize profitability while managing environmental risk. As fertility levels increase, crop response to added nutrients will decrease.

When nutrients are applied in excess of crop utilization, over time nutrient levels will gradually build up in the soil, or in the case of nitrogen, move out of the root zone.

There are two distinct goals for interpreting soil tests.

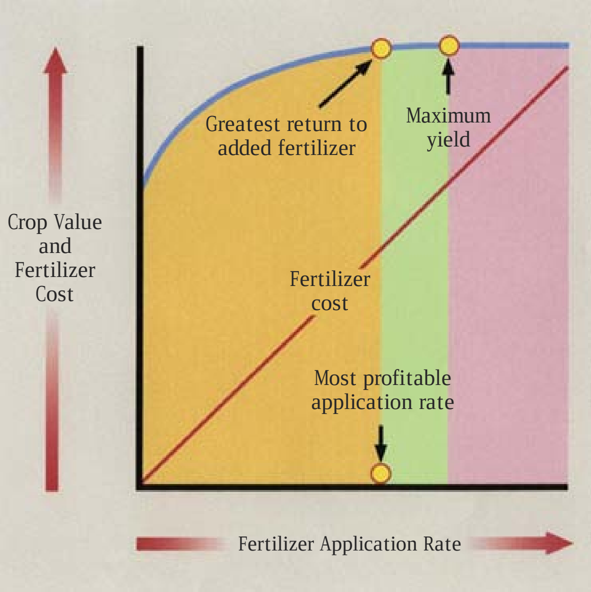
For lower-testing soils: aim to ensure adequate nutrient levels to optimize production, crop quality, and returns.

For higher-testing soils: plan nutrient applications to protect water quality. For example, when planting corn or wheat into soils with adequate but not extreme fertility levels, applying a liquid pop-up with the seed provides required nutrients closer to the seed, but at much lower volumes and incorporated into the soil.

In Ontario, crop fertilizer recommendations are based on the results of field trials conducted for each crop to determine the optimum rate for each level of soil fertility.

Agronomic nutrient requirements for P and K are based on soil test results. OMAFRA recommendations are based on the "nutrient sufficiency" approach. Agronomic N requirements are based on researched response curves for highest economic yield.

Crop yields show a diminishing return from increasing soil fertility beyond the point of maximum economic yield.



Most soil test results contain the information cited in the following chart.

TYPICAL INFORMATION IN SOIL TEST RESULTS

ITEM	DETAILS
SAMPLE NUMBER	• a reference in case a sample needs to be re-analyzed
pH AND BUFFER pH	• buffer pH is also provided when sample has a pH of 6 or lower • buffer pH indicates lime requirements to bring the pH of the soil back to 6.5 or higher • **if soil pH is <6.0, sufficient lime must be applied to the field to raise the soil pH to >6.0 prior to the application of sewage biosolids**
ORGANIC MATTER	• useful as baseline – soil organic matter improves soil quality
P AND K LEVELS	• the symbol HR means a high probability of response • LR means a low probability of response • NR means no or negative response – pertains to soils where additional nutrients will not give any economic yield return ○ this occurs at 60 ppm for P (for most crops) and 250 ppm for K ○ soil test values over these levels could reduce crop yield or quality and may increase the risk of water pollution • sites with soil test P >60 ppm are not eligible to receive sewage biosolids • in Ontario, only the sodium bicarbonate P test is acceptable for nutrient management planning
REGULATED METALS	• soils at proposed sewage biosolids application sites must be tested for the 11 regulated metals (As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Se, and Zn) ○ if any of the metal concentrations exceeds the regulatory limit, sewage biosolids cannot be applied to that field
NITRATES (for corn and barley only)	• in May to early June, take a 0.3 m (1 ft) depth soil sample • results indicate soil nitrate-nitrogen levels, and can reduce side-dress application rates

BIOSOLIDS TEST RESULTS

Biosolids test results are generally provided in parts per million on a dry weight basis. Be sure to use the correct basis (wet or dry weight) when inputting data.

Biosolids test results must be used to help determine total available nutrients and overall nutrient application rates.

The following principles must be addressed when interpreting biosolids test results:

- ▶ only a portion of the organic nitrogen is available for crop uptake in the year of application (estimated at 30%)
- ▶ residual N is derived from the organic fraction of biosolids.

It's estimated that 40% of the P from biosolids is available as fertilizer P in the form of P_2O_5 to crops in the year of application. An additional 40% will become available over the longer term and adds to the total of available soil P.

STEP 4 – DEVELOP OPTIONS

In Step 4, you interpret the flags and information you've received following the initial run-through of the nutrient management planning model. You develop and assess the options to come up with the best possible decisions for biosolids application on your farm operation.

Desired outcome of Step 4

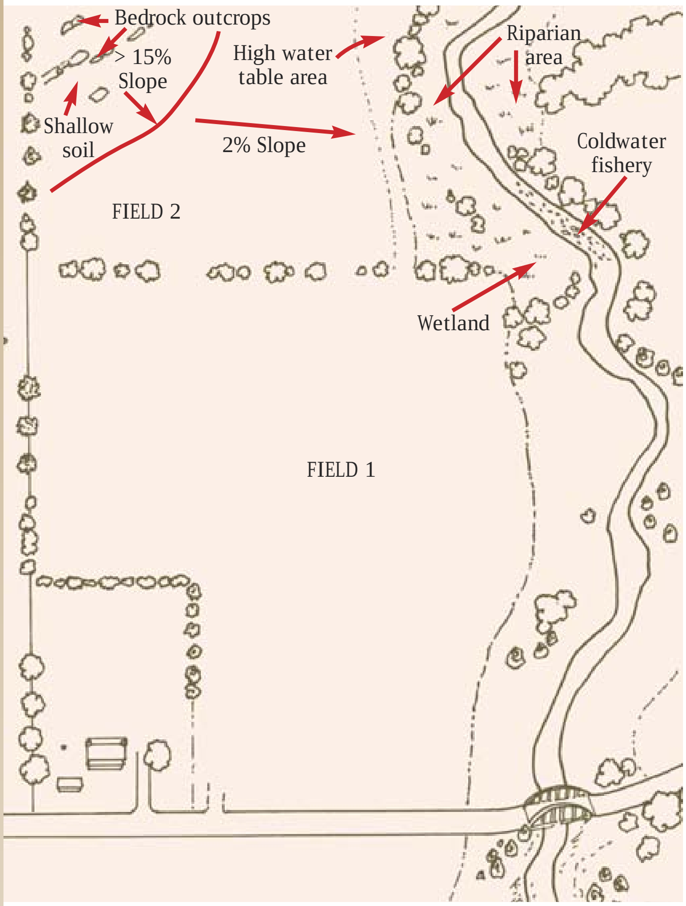
▶ **a systems approach that uses biosolids with the goal of maximizing economic benefit of these nutrients without compromising soil health, crop opportunities, and other farm operations**

Here you have the opportunity to explore options, to consider different management practices so that the impacts (e.g., on nutrient availability, application rates, environmental restrictions) can be compared.

Will some of the options result in changing your choice of cropland/fields for application? Or will they result in changes to application rates or setback distances?

Here are some of the areas you may wish to explore.

CONSIDERATION	DETAILS	IMPACT
APPLICATION RATES	• eliminating starter fertilizer	• increased application rate
	• soil test levels	• limited application rate • crop growth and quality • fertilizer rates reduced
CROP ROTATION	• specific crop nutrient requirements	• application opportunities • acreage adjustments
PHOSPHORUS INDEX	• tillage and residue management to reduce soil erosion – cross-slope	• reduced P Index
	• strip cropping and buffers	• reduced P Index
SEASON OF APPLICATION	• late fall application	• reduced application rate
	• use of cover crops with fall application	• increased application rate



Crop responsiveness to applied biosolids and the potential for contamination of surface water and groundwater vary with land and soil conditions.

Greater crop response to applied biosolids can be expected if:

- soil test P is low – sewage biosolids application can be used to increase P levels
- one or more micronutrients are deficient, and/or
- water infiltration is slow and runoff potential is high due to low organic matter and/or poor soil quality.

The **potential for environmental contamination is less** if:

- soil test P is low
- there is little or no chance of flooding
- the depth to water table exceeds minimum depth requirements and the soil has fine texture
- BMPs for erosion and runoff control are in place for fields with steep slopes, and biosolids are not applied when slope is more than 12%
- hydrologic soil group (HSG) is a B or heavier
- biosolids are not applied near wetlands, and/or
- the application is done with greater than the required minimum setback to sensitive features such as surface water or wells.

Sewage biosolids should be managed like other nutrient sources.

From the standpoint of nutrient management practices, sewage biosolids should be managed as other nutrient sources with regards to fertility levels, application rate, time of application, and maintenance of soil pH.

✔ Monitor soil pH when using biosolids on a regular basis. This is especially important when applying alkaline- or lime-stabilized sewage biosolids. If the soil pH goes above 7, zinc and manganese deficiencies could occur.

✔ Apply sewage biosolids at rates according to OMAFRA recommendations for nutrients and lime, based on soil test results and in accordance with limits set out in O.Reg. 267/03.

✔ Keep records of biosolids analyses, soil test data, dates and application rates.

✔ Review the metal analysis of soils before application. This may be useful for diagnostic purposes should problems arise. Follow application rate, setbacks, and other requirements in the approved NASM plan for the application site.

Nitrate-nitrogen soil test results can be used to adjust application rates of biosolids and reduce fertilizer costs.

NITROGEN RECOMMENDATIONS (kg/ha) FOR SPRING BARLEY BASED ON NITRATE-NITROGEN SOIL TESTS

SPRING SOIL NITRATE-NITROGEN 0–30 cm (kg/ha)	PRICE RATIO*			
	8	7	6	5
10	138	147	156	165
20	107	114	122	129
30	76	81	87	93
40	44	49	53	57
50	13	16	18	21
60	0	0	0	0

* Price ratio is the cost of nitrogen in the fertilizer ($/kg) divided by the selling price of the barley ($/kg).

COMMERCIAL FERTILIZER

In most cases where biosolids are applied, commercial fertilizer is still required for economic crop growth. This is especially true with corn crops if N needs can't be met with biosolids alone.

In many cases, phosphorus is the nutrient that limits the application rate. Because sewage biosolids are low in potassium, potash fertilizer may be required.

Management strategies for improving N and P utilization often concern starter fertilizers. Ask yourself:

- is the starter fertilizer required – is it giving any yield benefit?
- is there a benefit to using a low-rate liquid starter (if starter is required)?
- is there an opportunity to do a side-by-side comparison to determine if there is a benefit of using starter fertilizer – especially if soil P test is greater than 30 ppm (30 mg/L)?

P Index values and related flags may render otherwise preferred fields unsuitable for biosolids application. Consider soil conservation practices such as cross-slope strip cropping to retain eligibility for biosolids.

CONSERVATION PRACTICES

Several conservation practices and structures will reduce the risk of erosion and runoff.

- ✔ Manage residue – reduce tillage operations to increase the percentage of the soil surface covered by the residue of the previous crop, thereby reducing the risk of erosion and runoff.
- ✔ Consider contour and cross-slope tillage and planting (including strip cropping) to, in effect, reduce the impact of cropland slope.
- ✔ Install erosion control structures such as field terraces, water diversions, and water and sediment control basins to reduce the energy of overland flow, and shelterbelts using fast-growing trees such as hybrid poplars to reduce wind erosion.

CROPPING SYSTEMS

Cover crops will help to mitigate N loss and N Index flags. Some cover crops take up and hold (trap) nitrogen and other nutrients in their organic form during the off season.

Consider inter-row application of lower rates of biosolids into a growing crop. This system applies the N when the crop needs are highest, and when risk of loss is lowest. This is also a greenhouse gas mitigation BMP.

Crop rotation will give more opportunities for application.

No two farms are the same. This is why there is no recommendation that will fit every situation.

Here are some alternatives that fit into a whole farm management program and may help to schedule around timing of biosolids application.

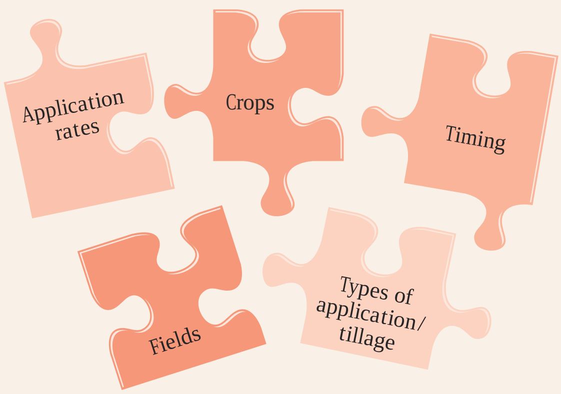
CROP	EARLY SPRING (after March 31st)	SPRING / SUMMER	FALL APPLICATION (before December 1st)
WINTER WHEAT	• drag hose • tanker – splash plate/ low-trajectory broadcast or dribble	• not suitable	• after harvest or prior to fall planting • pre-till to break macropores • tanker- or tractor-mounted injection system • suitable for dewatered biosolids
CANOLA	• pre-plant to help meet N requirements • avoid compaction • use tractor-mount drag hose	• not suitable	• after harvest or prior to fall planting • pre-till to break macropores • tanker- or tractor-mounted injection system • suitable for dewatered biosolids
SPRING GRAINS	• not suitable unless N requirement higher than average	• not suitable	• after harvest or prior to fall planting • pre-till to break macropores • tanker- or tractor-mounted injection system • suitable for dewatered biosolids
CORN	• suitable for pre-plant • may need to choose shorter-day varieties or silage • suitable for dewatered biosolids	• suitable if application equipment can adjust to standing crops • tanker – splash plate/low-trajectory broadcast or dribble	• after silage or grain corn harvest – most application equipment types can be used • suitable for dewatered biosolids
SOYBEANS	• only suitable for fields requiring low application rates • risk of lush growth leading to lodging and white mould	• not suitable	• after harvest • pre-till to break macropores • tanker- or tractor-mounted injection system • suitable for dewatered biosolids
FORAGE/PASTURE ensure regulation-required waiting periods are followed	• suitable for pre-plant or in conjunction with pasture renovation – where rotation provides grazing access delay	• between cuts – broadcast or injected – especially with high grass-content forage stands	• most suitable for forage that will be plowed down
COVER CROPS	• may be applied prior to tillage of a fall-established cover crop	• tanker – splash plate/low-trajectory broadcast or dribble	• tanker- or tractor-mounted injection system • suitable for dewatered biosolids

Most application equipment types can be used when sewage biosolids are applied after corn harvest.

Reducing tillage on candidate fields for biosolids application will reduce the P Index and provide more management options – including higher application rates and shorter separation distances.

STEP 5 – MAKE DECISIONS

Once the options are developed, it's time to make decisions on the best course(s) of action.



When selecting options for the application of biosolids, you need to consider:

- **which fields**
- **which crops and when in the rotation**
- **which soil and water conservation BMPs may be necessary to lower current N and P Index values**
- **timing and method of application – where negotiable**
- **whether to proceed**
- **application rate**
- **supplemental fertilizer.**

FIELD SELECTION

✔ Work with your agronomic consultant and/or certified NASM plan developer to select the most suitable fields among this list of candidates:

- ► fields without biosolids application within the past five years
- ► fields with properly documented application procedures
- ► fields with suitable soil and slope conditions
- ► fields without sensitive areas in the vicinity.

Fields without site limitations or without previous biosolids application may be ideal for application.

CROP SELECTION

✔ Choose crops that will benefit most:

- ► fertility records can help you determine fields requiring fertility buildup
- ► high N-use crops such as corn, cereals grains, and grassy forages will benefit from the N-supplying capability of biosolids
- ► although biosolids can be applied to fields where vegetable crops are to be grown, generally grain and forage crops are better choices for biosolids application due to the length of the required waiting period between biosolids application and harvesting of the vegetable crop

Schedule the timing of application to best match all operational considerations, such as field operations, weather patterns, and probable soil conditions.

TIMING OF BIOSOLIDS APPLICATION

The timing of biosolids land application must be scheduled around tillage, planting and harvesting operations, and will be influenced by crop, climate, and soil properties.

✔ Wait until conditions are suitable for tillage:

- ► traffic on wet soils immediately following heavy rainfalls may cause compaction and leave ruts in the soil, making crop production difficult and reducing crop yields
- ► muddy soils also make vehicle operation difficult and can create public nuisances by carrying mud out of the field and onto roadways.

✔ Apply when crops can use N:

- ► applications should also be made when crops will be able to utilize the N contained in the biosolids
- ► failure to do so could result in potential nitrate contamination of groundwater due to leaching of this water-soluble form of nitrogen.

✔ Use cover crops:

- ► fall applications should be followed with a cover crop to reduce erosion and runoff as well as leaching nitrogen.

✔ Use split applications:

- ► this may be required for liquid biosolids with low solids or nitrogen content
- ► in this way, a higher rate can be applied – in two or more applications when the soil cannot assimilate the volume of the higher rate at one time.

WHETHER TO PROCEED OR ADJUST

Remember that you have the right and responsibility to alter plans. You may want or need to if the site conditions, crop rotation, material quality, or other factors make the application operation unsuitable at the previously scheduled time. It's important to record all changes to the NASM plan at time of application.

Alternative timing of application to best match all operational factors is another consideration.

APPLICATION RATE

Biosolids application rates are based on crop removal or crop requirements ("agronomic N rate"). The relative concentrations of nutrients in biosolids are rarely present in the proportions required by the target crop. Supplemental fertilization may be needed to promote optimum vegetative growth and yield.

Nitrogen is required by crops in greater amounts than any other nutrient. That's why the crop requirements for most other nutrients are normally met when the agronomic N rate is applied. In addition, N is the nutrient most likely to be lost to surface water via tiles and groundwater if applied at greater than agronomic rates.

Some cautions regarding the determination of agronomic N rates are in order.

The amount of plant-available N can be underestimated or overestimated because the N composition of biosolids used to establish the average N concentration can vary during the period of time that samples are collected and analyzed to establish the agronomic N rate.

The equations used to calculate plant-available N are not site- or source-specific, and the actual amounts of plant-available N may vary from the target rates. These problems occur with other types of organic nutrient sources such as manures and yard waste composts, and are not unique to biosolids.

Only a portion of the total nitrogen present in biosolids is available for plant uptake. This plant-available nitrogen or PAN is the actual amount of N in the biosolids that is available to crops during a specified period. (See our earlier look at PAN on page 34.)

DETERMINING SUPPLEMENTAL FERTILIZER NEEDS

The amounts of plant-available nitrogen, phosphorus, potassium, and other nutrients added by the biosolids should be used to calculate the application rate. Supplemental fertilizers should be applied if the amount of any nutrients supplied by the biosolids is less than that recommended.

The amount of potassium (K) applied in biosolids can be calculated from biosolids composition data. Ninety percent of the K in biosolids can be assumed to be readily plant-available because K is a soluble element.

Example:

The following calculation is used to determine the amount of K_2O added in a biosolids application and supplemental K_2O required for a wheat field that has a K fertilizer recommendation of 100 kg K_2O/ha and receives biosolids containing 0.05% K at an agronomic N rate of 8 dry tonne/ha :

8 dry tonnes of biosolids supplies: 8000 kg/ha × 0.05% K = 4 kg K/ha

to convert K to K_2O:	K × 1.2 = K_2O 4 kg/ha × 1.2 = 4.8 K_2O/ha
Assuming 90% availability:	4.8 × 0.9 = 4.3 kg K_2O/ha
Assuming the fertilizer recommendation of 100 kg/ha the additional K_2O needed:	100 – 4.3 = 95.7 kg/ha

Have your NASM plan developer review the operational details of your plan with you.

STEP 6 – TAKE ACTION

It's time to put your NASM plan to work. It may not be followed exactly as planned due to unforeseen circumstances, change in conditions, and so forth. But now you have a solid framework for nutrient use in your operation.

The best reason to implement and follow a plan is to meet the goals set out at the beginning of the process.

✔ To put your plan into action:

- write down or obtain a computer printout of your plan
- work with your NASM plan developer to review the details of the plan with you, the biosolids applicator, and anyone else involved in the farm operation
- keep the plan in a location where it can be easily accessed for review
- prioritize the actions and be prepared for the scheduled application date
- consider weather, site conditions, field operation precautions, and recent concerns or plans of your neighbours.

FIELD CONDITIONS

✔ On the day of the scheduled application, check field conditions to ensure that:

- soil moisture is suitable for traffic and any pre-tillage operations
- field tiles are operating normally, e.g., no blowouts
- surface inlets are temporarily blocked – where necessary
- tile outlet controls are in place – where available
- tiles are not running. If water is flowing from the drainage tile outlet, consider pre-tilling the field.

WEATHER FORECAST

Weather, combined with soil moisture and drying conditions, can impact nutrient availability (especially nitrogen). Weather forecasts are useful when confirming pre-scheduled application dates.

✔ Monitor forecasts with special consideration of:

- wind direction (especially if there are residences downwind)
- relative humidity, and
- precipitation.

✔ Record this information at the time of application.

NEIGHBOURS AND NOTIFICATION

Many farm operations emit odours, produce noise or vibration, or cause dust. Some conflicts occur between biosolids users and neighbours. Unfortunately, such conflicts are not always handled as constructively as they might be. Conflict can be prevented: it takes a little know-how, a few skills and techniques, plus the right attitude.

The keys to preventing problems are neighbourly relations, good planning, and careful management.

✔ Get to know your neighbours. Help them feel comfortable enough to talk to you directly about their concern. This will help prevent the need for third-party involvement.

✔ Notify your neighbours of your intent to apply biosolids, and the precautions you are taking.

✔ Refer neighbours and other stakeholders to the biosolids generator or your certified NASM plan developer to answer technical questions regarding biosolids use.

✔ Follow your approved NASM plan, and ensure setbacks are maintained and in-field management minimizes offsite impacts.

SITE PLANNING

By following odour mitigation BMPs and taking neighbours' concerns into consideration, you'll be less likely to have odours as a point of contention.

✔ Locate transfer sites and field storage locations downwind from rural neighbours where possible.

✔ Keep stored materials and staging areas out of main view, if practical.

BMPs TO REDUCE ODOUR AND ODOUR COMPLAINTS
Odour management through setbacks and biosolids injection or incorporation is a regulatory requirement. These BMPs can assist in reducing odours and odour complaints.

BMP	DETAILS
INCORPORATE AFTER APPLICATION	• use tillage equipment to incorporate surface-applied materials • incorporate the same day of application to reduce the time for odour release
INJECT LIQUID BIOSOLIDS	• request that the materials are injected below the soil surface OR • incorporate the biosolids with a series of discs as they're applied on the soil surface
SCHEDULE YOUR APPLICATION	• carefully select the time of application – careful timing can decrease the opportunity for neighbours to experience the odour released • avoid spreading just prior to weekends or holidays when people are involved in outdoor activities • give special consideration to events planned at recreation areas near the land receiving the materials
CONSIDER WIND DIRECTION	• pay attention to the wind direction and, if practical, avoid spreading on days the wind is blowing toward neighbours or recreational areas
FOSTER NEIGHBOURLY RELATIONS	• maintain a co-operative public attitude • keep lines of communications open – hiding something generally arouses suspicion • be courteous even if your neighbours' requests are unrealistic • alert neighbours to date of application and discuss any plans they have for outside activities
KEEP RECORDS	• document all spreading activities so a record is available in case of problems • determine the cause of any complaint and work to correct it – good public relations go a long way toward improving acceptance of odours generated by biosolids application

For more ideas, see the OMAFRA factsheet *Farm and Neighbour Relations: Preventing and Resolving Local Conflicts,* Order no. 05-001.

When it comes to biosolids and neighbours, the good news is that BMPs for retaining biosolids-sourced nutrients – such as immediate incorporation, injection, and spreading on cooler days – will also reduce odours during application.

PRECAUTIONS FOR FIELD OPERATIONS

BMP Checklist for Application

✔ Notify residents within 450 m (1,476 ft) of the spreading site before application. Include:

- ► a copy of the site map
- ► estimated start and duration of operation
- ► contact name and number at the generating municipality or WWTP
- ► contact name and number for the contractor.

✔ Post signs in visible locations at the site entrance and along the frontage of land application sites.

✔ Have the contractor complete a pre-application checklist for each site verifying:

- ► buffers/setbacks have been flagged
- ► residents have been notified
- ► unsaturated soil depth has been verified
- ► the spreadable area is as planned
- ► proposed application rate and tonnage
- ► anticipated start date.

Post signs when applying biosolids to cropland.

BMP Checklist for Hauling

✔ Cover dewatered biosolids loads during transport to the field.

✔ Inspect truck prior to entering public roadways to ensure biosolids are not present on the outside of the truck. Ensure end gates and shut-off valves are closed and secure.

✔ Ensure any biosolids inadvertently tracked onto public roadways are removed the same day.

✔ Stockpile dewatered biosolids:

- ► cover stockpiles with a contiguous cover of soil, hay or other approved material
- ► provide a 200-metre (656-ft) minimum separation distance from any residence
- ► provide a 450-metre (1,476-ft) minimum separation distance from a residential area.

✔ Ensure targeted application rate does not exceed the amount specified in the NASM plan, depending on biosolids quality and permitted application:

- ► incorporate within two hours of spreading under normal conditions, and in all cases, before sunset
- ► leave no more than 10% of the biosolids on the surface after incorporation.

Cover dewatered biosolids loads during transport to the field.

Review your NASM plan and biosolids application plan with the applicator – specifically rates, separation distances and special site features.

SKETCHES FOR NMP AND BIOSOLIDS APPLICATION

Field sketches and maps are most useful during application when the applicator (yourself or someone hired) can see where materials will and will not be applied.

Sketches should have separation distances highlighted. Here are some examples:

- setback distances required from all wells
  - all wells within 100 metres (328 ft) of the field boundary for the field receiving biosolids
- direction of maximum sustained field slope – within 150 metres (492 ft) of the top of the bank of all surface water
- setback distances required from surface water established by the minimum separation distance
- location of all permanently vegetated buffer zones
- setbacks from rock outcrops and areas with shallow soil over bedrock
- identification of areas that are normally wet during the spring and fall
  - minimum depth of unsaturated soil conditions at time of application – this is required for fields where biosolids are applied
  - areas of a field where deep rutting occurs would be considered saturated
  - if a soil map shows poorly drained soils, this would indicate risk of saturated soil in the 30–60 cm (1–2 ft) range, while a soil map that indicates imperfectly drained soils would suggest a risk of saturated soils in the 60–90 cm (2–3 ft) range – unless the field has subsurface drainage
  - the other option to determine unsaturated soil depth is to dig test holes.

Using technology such as GPS mapping can significantly improve application accuracy and demonstrate compliance with regulated setbacks and application rates.

Preventing Preferential Flow

For the application of liquid biosolids on tile-drained soils, choose one or more of the following options.

- ✔ Monitor outlets and if biosolids are found in the tile drains, take appropriate action – stop application, block outlets (for at least 72 hours), and remove contaminated water (e.g., vacuum tanker).
- ✔ Pre-till to break macropores.
- ✔ Apply at a rate of less than 40 m^3/ha (3,600 gal/ac).
- ✔ Treat tile outflow to remove contaminants (e.g., biofilter, dispersion sandwich)
  - ► note that biosolids in subsurface drainage pipes can also become an issue when rainfall occurs shortly after application.
- ✔ Stop application immediately if discoloration is observed, then implement contingency plan.

For more information about monitoring tile flow, see Step 8.

On tile-drained soils, apply liquid biosolids at low rates when tiles are running.

WATERCOURSES

Regulation 267/03 under the Nutrient Management Act, 2002 requires a minimum 20-metre (66 ft) separation between the top of the nearest bank of a surface watercourse and the area of application of biosolids. Greater separation distances may be required depending on soil type, slope of the land, and application method used in the area near the watercourse. Separation distances are determined on a case-by-case basis.

STEP 7 – KEEP RECORDS

In order to review and revise a plan, you must know what was done. Record-keeping is the process of recording what **actually** took place.

Record-keeping is already a key component of many aspects of farming, such as financial book-keeping and recording crop and livestock yields. For NASM plans, there are several reasons for keeping records:

- proper records help to reconcile what was planned and the adjustments made at the time of application
- records demonstrate accountability and diligence – should something go wrong or if someone questions what was done (e.g., a nuisance complaint), having the records of what was done and when will help resolve questions and conflicts
- record-keeping is a regulatory requirement for biosolids application operations and NASM plans.

WHAT TO RECORD, POST-SPREADING

SUBJECT	DETAILS
SITE CONDITION	• conditions of the field entrance, staging area, and public roadways post-spreading • presence of biosolids on the road
POST-SPREADING CHECKLIST	• an inspection and checklist are completed by the contractor for each site indicating: ○ a visual confirmation that all biosolids have been incorporated with no more than 10% remaining on the surface ○ quantity of biosolids applied and location ○ date started and completed
COMPLAINT RESPONSE	• contractor should record all on-site responses and address all on-site queries and complaints by stakeholders
INFORMATION MANAGEMENT	• data from pre- and post-inspection reports are logged, including: ○ resident notification ○ lot and concession of site ○ date of start and end of spreading ○ area spread ○ total volume spread ○ rate of spreading ○ nutrient and metals loading

Record-keeping by the applicator is a regulatory requirement for biosolids application operations.

MONITORING AND RECORD-KEEPING

Computer-based and remote-sensing techniques have been developed to improve calibration, resource and input monitoring, as well as record-keeping techniques.

A map can be produced to verify setback distances. The data can be used by the local fertilizer dealer to compensate areas that did not receive biosolids with commercial fertilizer.

GPS technology improves precision of biosolid applications.

STEP 8 – MONITOR

Monitoring is the process of observing and recording. By using the records you've collected as a base, you can monitor your management practices for trends in your operation.

Over several years, the process will provide you with a solid foundation on which to base decisions and changes for meeting production and environmental targets.

STEP 1 Set goals
STEP 2 Take inventory
STEP 3 Input and analyze data
STEP 4 Develop options
STEP 5 Make decisions
STEP 6 Take action
STEP 7 Keep records
STEP 8 Monitor
STEP 9 Make adjustments to your NASM plan
STEP 10 Plan for the unexpected

WHAT TO MONITOR FOR	
SOIL	• increasing or decreasing soil phosphorus and potassium levels over a 10-year period • pre side-dress nitrogen tests to indicate nitrogen available for uptake by crops • compacted soils caused by application method or timing • changes in the concentration of regulated metals over time
CROPS	• yields and whether they're increasing or being maintained • side-by-side comparisons established and evaluated
WATER	• tile outlets: monitor before, during and after liquid application at one-hour intervals, 24–48 hrs after application to ensure that water is not contaminated • wells: sample well water regularly for fecal coliform and nitrates
BIOSOLIDS QUALITY	• biosolids analysis • concentrations of metals and nutrients applied
BUFFER STRIPS	• effectiveness of buffer strips: look for evidence of erosion and/or sedimentation or evidence of concentrated flow that indicates a grassed waterway may be more effective • effectiveness of buffer strips during intense or high rainfall events, which can result in surface runoff causing contaminated water
NEIGHBOURS	• comments/complaints from neighbours

Monitoring should take place whenever nutrients are applied to land. Most often, monitoring is simply a visual inspection just to make sure things are happening as planned.

APPLICATION ON TILED LAND – TILE OUTLETS

As touched on in Step 6, when applying to land with subsurface drainage, **monitor outfall (outlets) to ensure that biosolids are not entering surface water through preferential flow.** Look for discoloration of tile flow, relative to pre-application condition.

TILES SHOULD BE OBSERVED ON A REGULAR BASIS.

Here's a suggested schedule for observation:

- prior to application to determine the quality and quantity of flow (ideally there will be no flow)
- 10–20 minutes after start of application
- once each hour, if rate is greater than 90 m^3/hr (20,000 gal/hr)
- once each 90 m^3 (20,000 gal) if hourly application rate is less.

As an alternative to having a person monitor, consider using automated continuous monitors.

STEP 9 – MAKE ADJUSTMENTS TO YOUR NASM PLAN

After you've put your NASM plan into action, and the monitoring and record-keeping are underway, you're in a position to determine which decisions in the plan worked well and which did not.

As you contemplate making adjustments, remember to follow the systems approach to management.

A plan of this sort is a living document intended to change with time and technological advances, and with better understanding of the processes involved. It is most important to evaluate how well the plan met the goals set for it (Step 1).

Making adjustments to your plan is similar to repeating Steps 3 to 6 – the analysis, interpretation, decision and action processes. By going through the plan, making the required or desired changes, the end result will be a revised plan, ready for implementation.

When reviewing or making changes to your NASM plan, consider:

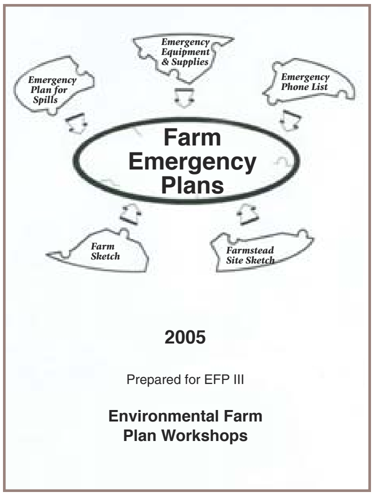
- changes to your plan – triggered by expanded acreages for biosolids application or the decision not to proceed with biosolids use
- personal changes that may affect long-term goals, labour availability, etc.
- greater understanding of the principles that may affect whether you, in consultation with your NASM plan developer, revise the plan
- market forces that may affect the livestock raised, crops grown, end use of products generated (including manure), acres of various crops, etc.
- neighbours' reaction and changes in the community (e.g., urban growth closer to the farm), bylaw changes, new regulations, etc. that may affect your choice to use biosolids
- biosolids sample analysis that may have changed since the initial results used for the original plan
- subsequent soil analysis that may show nutrient balance increasing over time
- commercial fertilizer rates or biosolids application rates that may have to be modified based on results from side-by-side comparisons
- new technology that may affect application rate or timing (e.g., application equipment, storage process such as anaerobic digesters or composting)
- purchase or rental of additional land base that may be required
- the changes made are in compliance with the most up-to-date version of O.Reg. 267/03.

If significant cropping management changes are planned, redo the NASM plan to reflect these changes.

STEP 10 – PLAN FOR THE UNEXPECTED

You need to be prepared for the unexpected. The best way to do that is to think ahead and plan what you would do if…?

A contingency plan is a written document that sets out actions to be taken in the event of an incident that presents an immediate environmental threat. For example, a tanker or biosolids nurse tank could leak or spill before application. Preparing a contingency plan in advance speeds up your ability to take corrective action on short notice. A NASM plan must contain a contingency plan that sets out actions in case of an emergency.



The EFP Emergency Plan is a good model for preparing for environmental hazards that could happen on your operation.

Spills Action Centre 1-800-268-6060

For additional information, please see the Ontario Ministry of the Environment's *Spill Reporting – A Guide to Reporting Spills and Discharges* (May 2007).

INCIDENT	ACTIONS
SPILL	
A spill is defined as a discharge of a pollutant into the natural environment that is abnormal in quantity or quality. Spills must be reported if they cause or are likely to cause any of the following: • injury or damage to property or animal life • impairment of quality of the natural environment – air, water, or land • adverse health effects • safety risk • making property, plant, or animal life unfit for use • loss of enjoyment of normal use of property • interference with the normal conduct of business.	In the event of a spill, the following steps will be taken: • spill area is contained to restrict public access • spill area is contained wherever possible to prevent movement to surface water or groundwater • contractor notifies Spills Action Centre • contractor cleans up the spill in consultation with Ministry of the Environment (MOE) • where there has been movement of biosolids into the natural environment, samples will be collected to assess the extent of contamination • all data collected is provided to MOE • incident report and chronology are logged.
ACCIDENTAL OVER-APPLICATION	
Over-application or application in restricted zones	In the event biosolids are over-applied or applied in restricted zones: • MOE is notified • the case is identified • affected areas are managed to ensure no or minimal environmental impact • MOE is provided with an incident report, including remediation if necessary, and changes to operating procedures to ensure incident does not recur.

LEGISLATIVE REQUIREMENTS

We've touched on Ontario's legal requirements and regulations throughout the book. This chapter summarizes:

- **biosolids-related laws and bylaws at the provincial and municipal levels**
- **roles and responsibilities for all those involved in the process of land-applying sewage biosolids.**

The regulatory requirements indicated here are those in place at the time this book was written. Individuals applying sewage biosolids to agricultural land must comply with the most recent version of all applicable regulations and legislation.

All municipal sewage treatment plants generate sewage biosolids as a by-product of the wastewater treatment process. Most sewage biosolids are generated by digestion, either anaerobic or aerobic, as a final stage of treatment at a municipal sewage treatment plant. On a regular basis, the digested biosolids must be removed from the treatment process and managed in some way generally off-site from the plant.

As we noted at the beginning, municipalities have several options for their biosolids. Each municipality will choose the most appropriate and environmentally acceptable biosolids management practice based on their specific situation and the volume and quality of their sewage biosolids.

The operation of municipal sewage treatment plants is regulated under the Ontario Water Resources Act.

The management of biosolids is regulated under the Environmental Protection Act and the Nutrient Management Act.

REGULATORY FRAMEWORK

ONTARIO WATER RESOURCES ACT (OWRA)

The operation of municipal sewage treatment plants in Ontario is governed by the Ontario Water Resources Act and associated regulations.

These facilities must be designed, constructed, maintained and operated in accordance with the strict requirements in a Certificate of Approval issued under section 53 of the OWRA by the Ministry of the Environment.

The operators of such approved plants must also be trained and certified under Regulation 129 made under the OWRA.

The Ministry of the Environment and the Ontario Clean Water Agency train and certify wastewater treatment plant operators and staff.

SEWER USE BYLAW

Any municipality in Ontario that owns a sewage treatment plant is responsible for ensuring it's maintained and operated in compliance with their Certificate of Approval. As part of their responsibility for effective wastewater collection and treatment, many municipalities have adopted and enforce a strict sewer use bylaw. Sewer use bylaws generally apply to industrial, commercial, and institutional wastewater dischargers. The bylaw sets criteria for the quality of wastewater being discharged to the municipal sewage collection system for ultimate treatment at an approved sewage treatment plant.

Enforcement of the sewer use bylaw can greatly assist the municipality in its effort to meet the final effluent criteria for the sewage treatment plant. Enforcement can also reduce the levels of contaminants that will be concentrated in the sewage biosolids generated by the plant.

It is through strict enforcement of the sewer use bylaw that a municipality can achieve and maintain a biosolids quality that meets the standards for utilization on agricultural land. (Standards are set out in Ontario Regulation 267/03.)

ENVIRONMENTAL PROTECTION ACT (EPA)

Any biosolids management activities following treatment at the sewage treatment plant are governed by the Environmental Protection Act. These may include incineration (if not located at a sewage treatment plant), hauling, storage, landfill, and application on non-agricultural land.

Ontario Ministry of the Environment enforcement staff are responsible for monitoring operations at wastewater treatment plants.

NUTRIENT MANAGEMENT ACT – 2002 (NMA)

The land application of sewage biosolids on agricultural land is a form of nutrient management and is therefore governed by the NMA. Prohibitions, separation distances, and crop waiting periods are specified in Ontario Regulation 267/03 under the NMA for sewage biosolids application.

Under Ontario Regulation 267/03, all agricultural land to which sewage biosolids are to be applied must have a NASM plan developed by a certified NASM plan developer and approved by the Ontario Ministry of Agriculture, Food and Rural Affairs. For more information about the Nutrient Management Act, Ontario Regulation 267/03 and associated protocols, guides and tables, please go to **www.e-laws.gov.on.ca**

STAKEHOLDER ROLES AND RESPONSIBILITIES

"All stakeholders, including operating agencies and other generators, haulers and farmers have certain responsibilities and rights to ensure that the final utilization of these biosolids is successfully carried out in an environmentally friendly manner with beneficial effects for the agricultural soil."

> from the *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land*

MUNICIPALITY

Municipalities are responsible for enforcing their sewer use bylaws and operating their sewage treatment plant in accordance with their Certificate of Approval issued under the Ontario Water Resources Act.

The Ministry of the Environment has developed a series of sector-specific wastewater treatment BMP documents that assist industries in developing their own operational practices to reduce or eliminate contaminants from entering the sanitary sewer. Wastewater treatment would only be considered if the industry could not reduce or eliminate contaminants by all other means.

If a municipality determines that their sewage biosolids meet the criteria for utilization on agricultural land, they must work with a NASM plan developer and the local farm community to secure approved NASM application sites.

The municipality must then either hire a licensed biosolids hauler or obtain the necessary approvals from the Ministry of the Environment to haul their own biosolids to an approved land application site.

The municipality is also responsible for providing alternative destinations if biosolids don't meet the criteria or can't be land-applied due to weather or field conditions. The municipality may delegate this requirement to the hauler/land application contractor.

The municipality should retain records related to the quality and quantity of the biosolids shipped to land application sites and site locations.

BIOSOLIDS HAULER – BROKERS, LAND APPLICATORS, AND TECHNICIANS

All biosolids haulers in Ontario must obtain Ministry of the Environment approval in the form of a Waste Management System Certificate of Approval. It is their responsibility to operate in compliance with their Certificate of Approval.

In many Ontario municipalities, the responsibility for selecting suitable sites for land application of sewage biosolids is delegated to a biosolids hauler/land application company. In this case, the hauler must work with the landowner or operator and a certified NASM plan developer to obtain the necessary NASM plan approval from the Ontario Ministry of Agriculture, Food and Rural Affairs.

The hauler is also responsible to ensure that the hauling of the biosolids is done in compliance with the Waste Management System Certificate of Approval. The biosolids land applicator, the farm operator, and the NASM plan developer are responsible to ensure that the land application information in the NASM plan is understood by all parties and that the biosolids are applied according to the plan.

The Nutrient Management Act and regulations require the following key players to be trained, certified and/or licensed:

- those who develop the NASM plans
- companies that do land application (prescribed materials application businesses), and
- operators of the land application equipment (nutrient application technician licence).

The biosolids land applicator must ensure that the materials are applied uniformly and do not exceed the maximum application rate. The operation should be scheduled such that it is mutually beneficial for the hauler and the farmer.

All candidate application sites must be assessed to verify that the proper conditions exist prior to approval for application.

The hauler must provide the farmer with a report indicating the fertilizer-equivalent values of the land-applied biosolids. This is essential for the farmer to make sound nutrient management decisions.

FARM OWNER AND OPERATOR

The farmer and the certified NASM plan developer should work together to develop a utilization program for individual fields.

The farmer has the right and responsibility to:

- insist on program flexibility such as application rates or timing
  - application rates should be adjusted to suit the nutrient requirements of the crop, as long as they're within the rate in their NASM plan
- stop or refuse biosolids from being spread on the approved site at any time
- ensure that biosolids are land-applied at times that are beneficial for crop production, but not disruptive to normal farming practices
- ensure that appropriate waiting periods between material spreading and cropping or pasturing are observed
- obtain advice from intended market sources as to other limitations or restrictions
- account for the sewage biosolids' nutrient value in his/her nutrient management planning calculations, if the farm is part of a farm unit that is required to have a nutrient management plan.

Farmers are encouraged to use cropland BMPs to optimize the benefit and minimize the risk of sewage biosolids land application.

ONTARIO MINISTRY OF AGRICULTURE AND FOOD AND RURAL AFFAIRS (OMAFRA)

When required by the Nutrient Management regulations, OMAFRA is responsible for the approval of NASM plans and the registration of operations receiving NASM.

OMAFRA also:

- ► provides scientific review and establishes land application criteria with the Ministry of the Environment and stakeholders
- ► reviews and approves the strategies of phased-in farms that are required to have a nutrient management strategy
- ► is responsible for the training, certification and licensing requirements as set out in the Nutrient Management regulations.

OMAFRA staff are responsible for the training, certification and licensing requirements as set out in the Nutrient Management regulations.

MINISTRY OF THE ENVIRONMENT (MOE)

MOE approves municipal sewage treatment plants under the Ontario Water Resources Act. Most sewage biosolids management activities are approved under the Environmental Protection Act. These may include hauling, storage, incineration (if not located at a sewage treatment plant), landfill, and application to non-agricultural land.

MOE is responsible for monitoring compliance with the regulatory components through inspections and investigations.

The ministry's continuing efforts include:

- co-development with OMAFRA of a regulatory framework based on sound science that both protects the environment and provides for a sustainable biosolids land application program
- fostering of continuous improvement through research, information transfer, and training
- development of training for licensing and certification
- ensuring compliance with the regulations and the use of practices that meet regulatory requirements in treatment, management, and land application programs.

With specific regard to agriculture, MOE is responsible for compliance under the Environmental Protection Act, the Ontario Water Resources Act, the Pesticides Act, and the Nutrient Management Act. All of this legislation, plus any associated regulations, protocols, and approvals, apply to agricultural operations.

MOE's compliance program is staffed with Agricultural Environmental Officers (AEOs) – provincial officers with specialized agricultural training. An AEO may visit a farm for a number of reasons, including:

- to perform an inspection to assess compliance with legislative requirements
- to respond to a complaint received by the ministry either from the public or through a referral from another agency (regardless of whether a NASM plan is in place)
- to respond to a report of an environmental incident or spill.

The MOE's on-farm compliance approach engages farmers actively to resolve issues. As the requirements are often complex, AEOs work directly with farmers to achieve compliance with the law.

CASE STUDY

The Jones family runs a mixed livestock and cash crop operation. They recently purchased two additional properties.

Mr. Jones knows that these properties would benefit from a manure application, but they are some distance from their livestock operation. Hauling manure to these farms would not be cost-effective.

One of Mr. Jones's colleagues in the local soil and crop organization has used biosolids in the past, and has been telling Mr. Jones that biosolids might be one way that he could apply nutrients and organic matter to his new farms.

STEP 1 – SET GOALS

Mr. Jones starts by evaluating the two new farms. He wants to get nutrients and organic matter applied to these fields, but he also knows that if the application is not done correctly, any benefit from the applied material may not outweigh the potential harm.

Mr. Jones sits down with the biosolids hauler from his area and the two of them start to develop a game plan to see if biosolids have a place in his operation. The biosolids hauler puts Mr. Jones in contact with a certified NASM plan developer. The three of them will work together to develop a NASM plan for the biosolids application on the Jones farm. Mr. Jones identifies the following goals:

- **timely application** – Mr. Jones does not want the spreading operation to delay his fieldwork. Timely application will be necessary if a spring application is scheduled.
- **agronomic considerations** – Mr. Jones wants to ensure that the crop receives enough nutrients, but he is also sensitive to the risks of over-application. He wants an even and accurate application to his fields.
- **information sharing** – Mr. Jones is adamant that he receive the soil data collected for these fields. He also wants the NASM plan developer to provide him with a completed NASM plan demonstrating how biosolids can fit within his cropping program.

Neighbours' opinion will be crucial to the consideration of regular biosolids use. Jones realizes that informed neighbours will be better than an alarmed community. Many neighbours will be appreciative of being consulted prior to the decision.

STEP 2 – TAKE INVENTORY

The two farms are broken up into six fields. Soil samples are collected from each field to ensure that each field is appropriate for receiving sewage biosolids. The results are shown in the table below.

FIELD	pH	PHOSPHORUS	POTASH
1	6.3	16	150
2	6.8	14	180
3	6.2	8	226
4	6.1	12	201
5	5.9	55	227
6	6.0	64	250

STEP 3 – INPUT AND ANALYZE DATA

Fields 1, 2, 3 and 4 all meet the criteria for biosolids application.

Field 5 meets the criteria for soil phosphorus concentration, but does not meet the minimum pH of 6.0, and therefore is ineligible to receive biosolids until the pH of the field is adjusted to above pH 6.0.

Field 6 exceeds the maximum soil phosphorus level, and is therefore also ineligible to receive an application of biosolids.

The following chart highlights some potential issues at the Jones farm, and presents alternative strategies that will resolve the problems and improve the nutrient management planning process.

As always, the changes must be practical and fit with the overall management of the farm operation.

POTENTIAL CHANGES FOR NEXT SEASON	CONSIDERATIONS
• consider not using starter fertilizer; apply additional N as carrier in herbicide	• allows increased application (over 1000 gal/ac) based on P_20_5 • removes N Index red flag from fall application since N over crop removal is reduced
• reduce application rate for corn	• reduces the phosphorus applied to a rate that may still be above, but is closer to, the amount removed by the crop (30–46 kg or 67–103 lb) • removes the red flag for P_20_5 crop removal balance • removes the red flag for PAN greater than 200 kg/ha ○ what is the impact of eliminating the starter fertilizer or going to a pop-up starter fertilizer for some crops? • how high are the soil test levels? • how will soil test results impact application rates? • how will they impact crop growth? ○ note: side-by-side comparisons are a good option to answer that question specifically for your operation • how much can you save in fertilizer costs?
• change tillage from mouldboard plough to mulch till • change direction from up and down slope to cross slope • measure slope length to show actual 244 m (800 ft) – instead of guessing • eliminate the starter fertilizer	• changes P Index from 36 to 22 in one of the fields • reduces BMP separation distance from 30.5 m (100 ft) to 20 m (66 ft) from surface water

Reducing tillage on candidate fields for biosolids application will reduce the P Index and provide more management options – including higher application rates and shorter separation distances.

The P and N Index restrictions prompted Mr. Jones to consider additional candidate fields for application. Suitable fields were included in the NASM plan.

STEP 4 – DEVELOP OPTIONS

Fields 1 and 2 are both scheduled to be planted to corn in the upcoming spring. The sandy soil texture of these fields might allow an early spring biosolids application. This would allow the crop to make use of more of the nitrogen in the biosolids.

Fields 3 and 4 are scheduled to be planted to soybeans. These fields have a clayey soil type and are therefore not suited to early spring application.

Next year, these fields will probably be growing winter wheat. This would allow for a late summer or early fall application next year after the wheat has been harvested. A cover crop can be established to help retain the nitrogen for the corn crop that will be planted the year after that.

STEP 5 – MAKE DECISIONS

Mr. Jones agrees to use biosolids on his two new farms. Fields 1 and 2 will be targeted for an application this spring. Fields 3 and 4 will be scheduled for an application after next year's winter wheat crop has been harvested.

STEP 6 – TAKE ACTION

The NASM plan developer works with Mr. Jones to develop a NASM plan. The plan balances the nutritional needs of the crop with the nutrients supplied by the biosolids and the supplemental commercial fertilizer applied by Mr. Jones. By making full use of the nitrogen and phosphorus components of the biosolids, Mr. Jones realizes that he is able to drastically reduce the amount of commercial fertilizer he needs to purchase to grow this crop of corn.

His NASM plan developer submits NASM plans for Fields 1, 2, 3 and 4 to the Ontario Ministry of Agriculture, Food and Rural Affairs for Mr. Jones. After review, the four plans receive approval. Biosolids will be applied to Fields 1 and 2 in the spring, and to 3 and 4 next year after wheat harvest.

When springtime comes, the hauler and Mr. Jones schedule the biosolids application for Fields 1 and 2. The application to Field 1 goes as scheduled, but the application to Field 2 is delayed. One of Mr. Jones's goals was timely application. He is not willing to delay his planting operation until the biosolids can be applied to Field 2.

STEP 7 – KEEP RECORDS

Mr. Jones keeps a number of records for all of his field operations, including the biosolids applications. He records the following information:

- application date
- application rate
- current and forecasted weather conditions
- most recent analysis of the biosolids applied to the field
- field conditions
- anything else of pertinence.

STEP 8 – MONITOR

Mr. Jones monitors the biosolids application at many levels, and at many times throughout the year.

Short-term monitoring considerations include:

- checking on the application crew to ensure that the actual application meets the regulatory standards and his own
- observing the crop to make sure there are no nutrient deficiencies
- monitoring the yield and crop quality to ensure these important parameters are maintained.

This fall and winter, Mr. Jones will use the information he collects regarding the biosolids application when evaluating the effectiveness of the program.

Long-term monitoring considerations include:

- ► ensuring soil test levels are kept within acceptable levels
- ► ensuring the biosolids hauler maintains proper field operations.

Mr. Jones will use this information to evaluate his continued participation in the program, and to evaluate whether he needs to make any adjustments to his current practices.

STEP 9 – MAKE ADJUSTMENTS TO YOUR NASM PLAN

Due to delays caused by wet weather, the biosolids application on Field 2 at the Jones farm has been postponed for two weeks.

When Mr. Jones informs the hauler that he cannot wait any longer to plant Field 2, they discuss the nutrient impact of this action. Mr. Jones will have to purchase commercial fertilizer to replace the nutrients that would otherwise have come from the biosolids.

The hauler does not want to lose Field 2 as a destination for biosolids, and Mr. Jones does not want to spend the extra money on commercial fertilizer if he does not have to. The two of them decide that inter-row application of biosolids after the crop has been established is an option. Mr. Jones warns the hauler that the tractor operator must be extremely careful not to destroy the corn crop during application. The NASM plan developer makes the necessary changes to the NASM plan to accommodate the inter-row application.

When the corn reaches the 6-leaf stage, Mr. Jones calls the biosolids hauler. The application team comes to Field 2, and through careful operation of the equipment, they are able to apply the biosolids between the rows of corn without causing harm to the crop. Mr. Jones has the tractor operator leave some check strips where no biosolids are applied so that he can evaluate the crop response to the biosolids application.

Mr. Jones records the application rate and timing along with other pertinent information for inclusion in the annual update that is required by the regulations.

STEP 10 – PLAN FOR THE UNEXPECTED

After planning for the use of biosolids on his farms, Mr. Jones and the biosolids hauler discuss potential issues that could arise during or after application, and potential resolutions to these issues. For example, due to his experience applying liquid manure to his own operation, Mr. Jones knows that unintentional spills are a possibility. Since liquid sewage biosolids will be used at his farms, Mr. Jones and the biosolids hauler discuss what will be done in the event of a spill.

During application to Field 1, one of the neighbours is upset by the number of trucks that are using the road. She is concerned that the trucks will be a hazard to the school bus. When she finds out that biosolids are being applied to the site, she becomes more concerned and starts to ask where she can find out more information about this practice. The truck driver gives the neighbour contact information for the biosolids hauler and for Mr. Jones.

Once contacted by the neighbour, Mr. Jones is also concerned about the traffic patterns of the trucks affecting the school bus. He contacts the hauler to discuss possible options. They determine an alternative access to the field that effectively eliminates the traffic congestion issue before the school bus needs to use the road.

The neighbour appreciates the quick action on the traffic issue, but is still concerned about the land application of biosolids in general. The hauler is able to show the neighbour that the application program is being done in accordance with all applicable laws, and Mr. Jones is able – thanks to the NASM plan – to show that the nutrients being supplied by the application are at appropriate levels to be used by the crop.

The hauler also provides the neighbour with some reading material that explains the rules, regulations, potential benefits and potential concerns presented by the land-applied biosolids. The neighbour leaves, perhaps not totally in favour of the program, but well-armed to find out more information to make her own decisions regarding the practice.

GLOSSARY

Beneficial use	• use of a product with a defined benefit, such as biosolids used as soil amendment • disposal, such as landfilling or incineration, is not beneficial use
Biosolids	• organic fertilizer or soil amendments produced by the treatment of domestic wastewater • biosolids consist primarily of dead microbes and other organic matter
BMPs – Best Management Practices	• operating methods that ensure the proper land application of biosolids for protection of the environment • include agronomic loading rates, slope limitations, soil pH limitations, buffer zones, public access restrictions, grazing deferments, soil conservation practices, restrictions for saturated and frozen soils, protection of endangered species, and other site restrictions
Dewatering, dewatered biosolids	• process used to remove water from biosolids, producing dewatered biosolids that contain equal to or greater than 20% dry solids
Disposal	• method of final disposition that does not provide any beneficial use • includes landfilling and incineration
Groundwater	• the subsurface water within the zone of saturation • moves under the influence of gravity and is, in many instances, a source of well water for domestic and agricultural use
Heavy metals	• 11 elements that must be measured in biosolids and soils that are to receive biosolids, including arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn)
Incorporation	• mixing biosolids with the soil • includes injection, mouldboard ploughing, roto-tilling, chisel or disk ploughing, and tandem disk harrowing
Land application	• beneficial use of biosolids applied to land based on crop needs and the composition of biosolids
Leaching	• the movement of soluble components in solution from the soil by water
Municipal (domestic) wastewater	• wastewater from restrooms and sanitary systems of residences, cities, mobile home parks, subdivisions, restaurants, rest homes, resorts, motels, factories, stores and other commercial businesses • also includes industrial contributions when domestic and industrial wastewaters are combined in a city sewer system
Pathogen	• an organism capable of causing a susceptible host to develop a disease or infection
Plant-available nitrogen (PAN)	• a calculated quantity of nitrogen made available during the growing season after application of biosolids • PAN includes a percentage of the organic nitrogen (30% in year 1), a percentage of the ammonium N (depends on pH and incorporation), and all the nitrate-nitrogen in the biosolids
Septage	• the biodegradable waste from septic tanks and similar treatment works • includes the sediments, water, grease and scum pumped from a septic tank
Sewage biosolids	• the solid, semi-solid or liquid residue removed during the treatment of wastewater
Soil pH	• an index of the acidity or alkalinity of a suspension of soil in a liquid such as distilled water or dilute salt solution • the index is the logarithmic expression of the chemical concentration activity of H-ions in the liquid surrounding the soil particles • a pH >7.0 is alkaline and <7.0 is acid • a soil pH is not a measure of total acidity in a soil – it's a measure of the acidity or alkalinity of the soil
Soil profile	• a two-dimensional view of the soil from Earth's surface down to and including the parent material
Soil saturation	• the water content of a soil beyond which no more water is absorbed
Surface runoff	• the water flow that occurs when soil is infiltrated to full capacity, and excess water (from rain, snowmelt, or other sources) flows over the land
Vectors	• rodents, flies, mosquitoes or other organisms capable of transporting infectious agents

Agencies and Offices

Ontario Ministry of Agriculture, Food and Rural Affairs
Agricultural Information Contact Centre
1 Stone Road West
Guelph, ON N1G 4Y2
ph: 1-877-424-1300
email: ag.info.omafra@ontario.ca
web: www.omafra.gov.on.ca

Ontario Ministry of the Environment
Public Information Centre
1st flr., 135 St. Clair Avenue West
Toronto, ON M4V 1P5
ph: 1-800-565-4923
email: picemail.moe@ontario.ca
web: www.ene.gov.on.ca

For More Information

To obtain your copy or a link for downloading, please see the appropriate contact information under Agencies and Offices.

MOE

Spill Reporting – A Guide to Reporting Spills and Discharges (May 2007)

OMAFRA

Farm and Neighbour Relations: Preventing and Resolving Local Conflicts, Order. no. 05-001

Septic Smart www.omafra.gov.on.ca/english/environment/facts/sep_smart.htm

Soil Fertility Handbook, OMAFRA Publication 611

FACTSHEETS, INFO SHEETS, Q and As
www.omafra.gov.on.ca/english/nm/nasm.html
www.ene.gov.on.ca/en/land/nasm

NUTRIENT MANAGEMENT LEGISLATION IN ONTARIO
Ontario Regulation 267/03
www.e-laws.gov.on.ca
Nutrient Management Act, 2002 – O.Reg. 267/03

BMP SERIES (see pg. i for a complete list)
Irrigation Management
Managing Crop Nutrients
Manure Management
Nutrient Management Planning

Acknowledgements

The Best Management Practices Program is a partnership of Agriculture and Agri-Food Canada, the Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Federation of Agriculture.

FUNDING

Funding for this publication has been provided by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs.

CONTRIBUTORS

Task Team Chairperson – Ontario Ministry of Agriculture, Food and Rural Affairs: Michael Payne

Task Team and Authors (in alphabetical order) – Ontario Ministry of Agriculture, Food and Rural Affairs: Benoit Lebeau, Dale McComb, Arlene Robertson, Larry Schut, H.J. Smith, Ted Taylor; Ontario Ministry of the Environment: Shelly Bonte-Gelok, Cecily Flemming, Mohsen Keyvani, Sonya Kleywegt, Glen Ross; Ontario Clean Water Agency: Brent Zehr; Region of Waterloo: Frank Moffat; Ontario Federation of Agriculture: Larry Davis, Wendy Omvlee

Photographers – Kerry Little, H.J. Smith

Technical and Visuals Coordinators – Ontario Ministry of Agriculture, Food and Rural Affairs: H.J. Smith, Ted Taylor

Editor – Alison Lane

Watercolour Illustrations and Sketch Artist – Irene Shelton, Winduncroft Studio, Belwood

Graphic Designer – Neglia Design Inc.

Canada

Ontario

OFA Ontario Federation of Agriculture